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ON THE

Organs of Respiration

Read at the

ROYAL COLLEGE OF PHYSICIANS

at London, A. D. MCCXXXIII.

By J. N. G.

The Gallifreyan Librarian has this

To which is added

An APPENDIX, containing Remarks on some Observations
of Dr. Huxham's, published in the Transactions of the
Royal Society, for the Year 1734.

By J. N. G. M.D. F.R.S. Doctor of Physick, Ju-
nior of the College of Physicians, and of the
Royal Society.

LONDON:

Printed by W. Widdowes, and sold by J. Roberts in St. Pauls Church-yard.

T H R E E

L E C T U R E S

O N T H E

Organs of Respiration.

Read at the

ROYAL COLLEGE of PHYSICIANS
at *London*, A. D. MDCCXXXVII.

B E I N G

The GULSTONIAN LECTURES for that Year.

To which is added

An APPENDIX, containing Remarks on some Experiments
of Dr. HOUSTON's, published in the TRANSACTIONS of the
ROYAL SOCIETY, for the Year 1736.

By BENJ. HOADLY, Doctor of Physick, Fel-
low of the COLLEGE of PHYSICIANS, and of the
ROYAL SOCIETY.

*Non fingendum, aut excogitandum, sed inveniendum, quid Natura faciat,
aut ferat.*

BACON.

L O N D O N:

Printed for W. WILKINS; and sold by J. ROBERTS in *War-*
wick-Lane. MDCCXL.



AN APPENDIX, CONTAINING REMAINS OF THE
OF DISSECTION, PUBLISHED BY THE TRANSACTIONS OF THE
ROYAL SOCIETY, FOR THE YEAR 1756.


By BENJ. HOBBS, Esq. of Ipswich, M.D.
Low of the College of Physicians, and of the
ROYAL SOCIETY.

Non parvum, cuiusmodi, et quomodo, cum Nona, et
cum Nona.

LONDON:
Printed for W. Wilson, and sold by J. Roberts in Wm.
with Low, Aldgate.

TO
Dr. P E L L E T,
P R E S I D E N T
OF THE
ROYAL COLLEGE of PHYSICIANS,
L O N D O N.

S I R,

S the following Lectures were undertaken at Your Request, it was no small Satisfaction to me to find they so far answered Your Expectation in the Hearing, as to make you desirous they should appear in Print. And I own, it was with some Pleasure I yielded to Your repeated Instances to that Purpose, because I thought they gave me a sort of Claim to Your Patronage.

BUT tho' Your Name would have been a sufficient Apology for my sending them to the Press exactly as they were read ; I could not help thinking I owed so much
to

to Your Character, as to let nothing appear in them, which I could express in a clearer Manner, or set in a truer Light.

FOR this Reason, I sat down to consider them more carefully, than I had done before ; and soon found Occasion not only for altering, but for enlarging, them in several Places.

SUCH as they are, I readily submit them to the Publick : and am glad of the Opportunity they give me of paying you a grateful Acknowledgment for the many Civilities I have received from You : which I hope You will permit me to look upon as Marks of a Friendship, which I shall always esteem as the greatest Honour and Happiness.

I am,

S I R,

Your most obliged

Humble Servant,

B. HOADLY.



LECTURE I.

OF THE

ACTION *of* RESPIRATION.

I HAVE fixed upon the Organs of Respiration, their Use in the Animal Oeconomy, and the Diseases to which they are liable, for the Subject of these Lectures.

IN the First, I shall consider the Make and Action of those Parts only which are principally concerned in easy and undisturbed Respiration, in order to point out more plainly by what peculiar Mechanism it is usually performed in Health.

IN the Next, I shall lay before you the different Opinions of Authors concerning the Use of Respiration in the Animal Oeconomy; and endeavour to explain what it is that makes a constant Supply of fresh Air so necessary to Life.

AND in the Last, I shall shew from how many different Springs the Diseases arise, to which the Organs of Respiration are liable; and, conformably to the Design of the Founder of

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these Lectures, I shall enlarge a little upon the Method of Cure to be followed in the most dangerous of these Diseases.

IN pursuing this Design, I shall no where descend to a very particular Description of the Construction of the Parts, except where that Construction, or the Design of it, is disputed: because the Make of the Parts in general is too well known to require a particular Description *in this Place*; and the Philosophical Reasonings, which naturally offer themselves, will draw out these Discourses to a sufficient Length.

LET us begin then with taking each of the Actions necessary to Respiration separately into Consideration.

IN Inspiration, whilst the Air is taking in at the Mouth and Nostrils, the Chest is very perceptibly raised upwards, and the Abdomen pressed forwards; by which the Cavity of the Breast is enlarged.

IN Expiration, the Chest subsides, the Abdomen is drawn in, the Cavity of the Breast is diminished, and the Air is breathed out again.

FROM attending only to the outward Appearances of one, who breaths easily and freely, this is all that can be observed.

BUT when our Curiosity leads us to enquire into what passes within, we find the Lungs themselves in Inspiration, dilating so as to receive the Air, thus taken in; and in Expiration, contracting so as to throw it out again.

WHEN Respiration is disturbed, the same Actions are performed, but with greater Difficulty. Thus you will sometimes see the Neck stretched out, the Head erect, and the Muscles of the Neck and Shoulders labouring together to raise the Chest, and enlarge its Cavity: and, at other times, when the Diaphragm and Abdominal Muscles do by themselves perform so much of the Action of Respiration, as is necessary to support Life; you will see the Contents of the Abdomen alternately and remarkably squeezed into the Cavity

vity of the Breast, and forced out again, whilst the upper Ribs and Shoulders remain quiet and unmoved.

FROM these Efforts of Nature in Distress, we see the Necessity there is, that the Cavity of the Breast should be alternately enlarged and contracted, for the carrying on the Action of Respiration. But they are not sufficient to convince us, that all the Parts of the Body, which at such a Time are ready to lend their Assistance, are absolutely necessary, or are always employed in the Action of Respiration, when it is performed freely, and with Ease.

IN the same Manner, since the Action of the Lungs can never be the Object of our Sight, without opening the Chest of an Animal alive; the Pain it must of Consequence be in, must occasion a violent and unnatural Dilating and Contracting of the Lungs. From this, indeed, we may be certain, that the Lungs dilate and contract, to receive and throw out the Air; but it will by no means follow, that they always do it with so much Force, or in so great a Degree.

So that we may easily make too hasty Conclusions, and lead ourselves into an Error, if we form our Notions of natural Respiration from Observations made upon a laborious or convulsive one.

OUR first Enquiry therefore shall be, in what Manner the Chest is formed; and what Muscles are employed in raising and depressing it, in order sufficiently to enlarge and contract its Cavity, for the carrying on an easy and free Respiration.

THE Fabrick of the Ribs, the Sternum, the Vertebrae of the Back, and the Diaphragm, to form the Cavity of the Breast; the Division of this Cavity into two, by the Mediastinum; the filling up the Intervals between the Ribs by the Intercostal Muscles; and the elegant and compleat Lining of the whole Cavity by the Pleura, for the more safe, warm,

and convenient Situation of the Lungs and Heart; are so well known, that they need no particular Description.

THE Ribs, together with their Cartilages, may in general be compared to so many Segments of different Curves, articulated at one End into the Vertebrae of the Back, and fastened at the other to the Sternum.

NOW if the boney Substance of the Ribs reached quite to the Sternum, and was firmly connected to it; the whole Set of Ribs, together with the Sternum, could have but a very inconsiderable Motion, if any at all: and this must be one Motion in common to them all.

BUT as the Ends of the Ribs, where they are connected to the Sternum, are formed of a yielding and elastick Substance, each Rib may be considered separately, as moving up and down upon both its Ends: One of which, at the Vertebrae, is absolutely a fix'd Center of Motion; whilst the other, at the Sternum, is but partly so, the whole Sternum readily conforming itself to the joint Motion of all the Ribs, either up or down.

CONSEQUENTLY, the Motion of the Breast, in the Action of Respiration, must be compounded of all the different Motions of the Ribs and Sternum: And therefore, if we designed an accurate and compleat Description of this Motion of the Breast, we ought to take into our Consideration all the minutest Differences in the Make of the Ribs themselves, as well as in the Manner in which they are connected to the Vertebrae, to the Sternum, and to one another. But as our present Design is only to explain in general, by what Mechanism the Cavity of the Breast is alternately enlarged and diminished; it will be sufficient, to imagine a Number of Planes drawn thro' every Pair of opposite Ribs, and making a Number of Angles with the Back-bone. It will then be easy to see that the more acute these Angles are, the less will the Cavity be which is

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contained within the Chest; and the less acute they are, the greater will that Cavity be: and, consequently, if the Ribs can be moved alternately, so as to make these Angles more and less acute, such a Motion will alternately enlarge and contract the Cavity of the Breast.

IN determining what Muscles are employed in performing these Motions, Anatomists are greatly divided: But if an Experiment may be depended upon, which I find mentioned by several Writers upon this Subject; we may safely conclude, that the Intercostal Muscles (among which, I mean to reckon the Super- and Intra-Costales, described by *Verheyen*) are sufficient to perform them, in the easy and natural Respiration we are now accounting for.

THESE Authors affirm, That when all the Muscles, except the Intercostal Muscles, which are any where about the Breast inserted into the Ribs and Sternum of a Dog, were entirely divided, whilst the Dog was alive, the Ribs continued in the same Motion as before.

NOW, tho' we should depend upon the Truth of this Experiment, and throw every Muscle, except these, out of our Consideration, as of little or no Service, unless where a laborious and forcible Respiration is wanted; we shall still find the Anatomists as much divided in their Opinions *how* these Muscles act, as they were before *which* were the Muscles concerned in Acting.

LET us therefore examine the Origin, Insertion, and Direction of the Fibres of the Intercostal Muscles; and see whether, from their Make, we cannot gain some Insight into the Manner of their Acting.

BETWEEN every two Ribs on the same Side, there is a Space, which is filled up with Muscular Flesh, in which two different Ranges of Fibres are plainly to be distinguished; one on the Outside, and the other within: which are called the Intercostal Muscles.

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THE *external* Range of Fibres runs obliquely *down*, from behind forwards, having one Extremity fastened to the *lower* external Edge of the superior Rib, and the other to the *upper* external Edge of the inferior Rib.

THE *internal* Range of Fibres runs obliquely *up*, from behind forwards, having one Extremity fastened to the *upper* internal Edge of the inferior Rib, and the other to the *lower* internal Edge of the superior Rib.

THUS do these Ranges of Fibres run in opposite Directions, and intersect each other.

Borelli, and after him, others who have attempted a Mechanical Account of Respiration, look upon the whole fleshy Substance, which fills up the Interval between every Pair of Ribs, as one Muscle; and give to both Orders of Fibres, the same Office of raising the Ribs.

Willis, on the contrary, espousing the more ancient Opinion, imagines, that each of these Ranges of Fibres has it particular Office; that whilst one of them contracts, the other lengthens; and, consequently, upon their acting alternately, that the Ribs are, by turns, elevated and depressed.

Borelli has endeavoured at a Demonstration of the Impossibility of these Orders of Fibres ever performing the contrary Offices of dilating and contracting the Thorax.

Willis, indeed, offers no Demonstration; thinking every one, who sees how opposite their Fibres run, must immediately allot them Offices as opposite.

Borelli suffers himself, at setting out, to be drawn into a remarkable Error. He takes only two Ribs into Consideration; and shews plainly enough (what no one will go about to deny) that neither of the Ranges of Fibres, which lie between, can, by their Action, push those Ribs asunder: The Consequence of which would plainly be, that as the Office of one is to draw the lower Rib towards the upper, the other Range cannot possibly be an Antagonist to it. BUT

BUT if he had taken three Ribs together, and observed the different Ranges of Fibres in the two Intercoſtal Muſcles, which lie on each Side the middlemoſt of theſe Ribs; he would have ſeen, at firſt Sight, that the internal Range in the lower Muſcle counter-acts directly the external Range in the upper Muſcle.

THUS (Fig. 1.) let AB, CD, EF , be any three Ribs, lying next in order to one another, and moveable upon their Ends A, C, E . Let ad, ad , be the Direction of the external Range of Fibres in the upper, and de, de , the Direction of the internal Range of Fibres in the lower Intercoſtal Muſcle.

Is it not plain, even at firſt Sight, that if the Fibres, ad, ad , ſhorten, they will pull CD up towards AB ; that if the Fibres, de, de , ſhorten, they will pull CD down towards EF ; that the Fibres, ad, ad , cannot ſhorten, unleſs the Fibres, de, de , lengthen, and give way to them; nor de, de , ſhorten, unleſs ad, ad , lengthen: and conſequently, that when both theſe Ranges endeavour to act at the ſame Time, the middle Rib will remain in the ſame Place, without any more Motion, than if they had never endeavoured to act at all? Do not theſe Fibres therefore plainly appear to have all the characteriſtick Marks of antagoniſt Muſcles?

IF the ſame Figures were made for all the Ribs, and their Intercoſtal Muſcles, all the external Ranges of Fibres would be nearly parallel to ad, ad : and if they be ſuppoſed to act at once, would pull all the Ribs up, except the Uppermoſt.

IN the ſame Manner, all the internal Ranges of Fibres would be nearly parallel to de, de ; and if they acted together, would depreſs all the Ribs except the inferior ones: which Office the *Serratus Poſticus Inferior* is very remarkably contrived to perform with great Force. To be convinced of which, there needs no more than to conſult *Euſtachius's* Tables. Tab. xxxvi.

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SINCE then these Ranges cannot both be contracted at the same Time; and, when they contract separately, one Set elevates and the other depresses the Ribs: is it not highly reasonable to conclude, that they were designed by Nature to act separately, and successively to each other?

WHEN, likewise, we consider that it is in our Power to stop the Action of Respiration in whatever Part of it we please, for some time at least; is it not reasonable to believe we do it, as in other Cases of the like Nature, by exerting a proportionable Degree of Force in both these Ranges of Fibres at the same time, so that neither may prevail?

THUS much in general upon the Action of these Muscles. Whoever will go more minutely to work, will find himself more fully satisfied of the Truth of what is here said: But my present Design will not allow me Time to be more particular.

WE shall next examine into the other external Appearance in Respiration; the alternate Motion of the Abdomen, in and out.

IN performing this Action, the Diaphragm, the Abdominal Muscles, and the Air within and without the Body, are all of them concerned in their Turns.

THERE will be no Occasion to give an accurate Description of the Diaphragm; it being sufficient for my Purpose to observe, that it is fasten'd at the edge, all the way on each side between the Back-bone and the Sternum, to the Bastard Ribs, and to one, or perhaps two, of the True Ribs, crossing each of them nearer their cartilaginous Endings as it approaches the Sternum; that it accurately separates the two Cavities, so that no Fluid can pass from one to the other, whilst it is whole; that when it is relaxed, and the Ribs depressed, its Duplicatures form as it were two Purses, convex towards the
Thorax,

Thorax, which consequently take up room in that Cavity; and lastly, that when the Diaphragm is stretched, and its Muscular Fibres act, its Duplicatures are drawn out, and its Surface is reduced nearly to a Plane.

AT the same Time, therefore, that the external Ranges of Fibres in the Intercostal Muscles raise the whole Set of Ribs, they must, together with them, raise the Edges of the Diaphragm; and with the Assistance of its Muscular Fibres, reduce its Surface nearly to a Plane. The Consequence of which, externally, is the apparent Swelling of the Chest and the Motion of the Abdomen outwards; and internally, a considerable enlarging of the Cavity of the Thorax.

To these Actions immediately succeed the Actions of the *Serratus Posticus Inferior*, and of the internal Ranges of Fibres in the Intercostal Muscles, which draw the Ribs down into their former Situation, and with them the edges of the Diaphragm. At the same time the Muscular Fibres of the Diaphragm cease to act; so that the external Air, assisted by the Action of the Abdominal Muscles, on the Contents of the Abdomen, is at free Liberty to squeeze the Diaphragm up into the Cavity of the Thorax again: The Consequence of which is internally diminishing the Cavity of the Thorax; and externally, the apparent subsiding of the Chest, and the Motion of the Abdomen inwards.

LET us now examine what is at the same time performed by the Lungs themselves.

THE Inside of the Lungs is by their Situation and Make, every where exposed to the Pressure of the external Air, which has a free Access to it thro' the Wind-pipe: But the Outside is so carefully enclosed in the Cavity of the Breast, that no visible way is to be found for the external Air to insinuate itself into it: and therefore it has perhaps too hastily been concluded, that there is absolutely no Air ever contained within the Cavity of the Breast.

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THIS Opinion has the more readily been embraced, as it furnished an easy Solution of the Dilatation of the Lungs in Inspiration. For when the Cavity of the Breast is enlarged, and there is nothing within it to press upon the outward Surface of the Lungs, it is easy to see that the external Air must, with all its weight, force itself into them, and by its Elasticity dilate every the minutest Vesicle of which they are composed.

NOTWITHSTANDING the Ease with which Inspiration is thus accounted for, this Hypothesis (for it deserves no better a Name) labours under many and unsurmountable Difficulties: which it were easy to mention, if the Point in dispute did not admit of experimental Proof; as will appear from some Experiments taken from Dr. Hales's *Hæmæstatics*, Page 83.

HE " slit Holes thro' the Intercoastal Muscles on each side
 " of the Thorax of a Kitten, and then placing it under an
 " Air-Pump-Receiver, he killed it in Vacuo. On opening its
 " Thorax, he found the Lungs *very red with coagulated*
 " *Blood*; which had flowed more freely into their Blood-Ves-
 " sels on the weight of the Atmosphere's being taken off of
 " their Vesicles, both within their Cavities, and on their sides
 " next the Thorax. Whereas if a Kitten be killed in Vacuo,
 " without having Orifices made into its Thorax, the Lungs
 " will in this case be *very white*; for whilst the Air is drawn
 " away from the Vesicles thro' the Bronchia, the Air, which
 " is included in the Cavity of the Thorax, being dilated, *com-*
 " *presses the Lungs, and squeezes the Blood out of its Ves-*
 " *sels*, on which Account they are in this case found to be
 " *white.*"

" AND that the Air in the Thorax thus compresses the Lungs
 " in Vacuo, is evident hence. If the Body of a Kitten, as soon
 " as killed, be cut asunder, just below the Diaphragm; and a
 " Weight be then tied to the Head, so as to make the obtrun-
 " cated Part sink under Water; and if in this Position, it be
 " placed

“placed in Vacuo, the Diaphragm will dilate considerably,
 “and subside again as soon as the Air is let into the Receiver.”

“A plain Proof (says the Doctor) that there is Air in the
 “Cavity of the Thorax; which, whilst it thus, by its Expansion, dilates the Diaphragm, must needs at the same time
 “compress the Lungs; in which State they are found on opening the Thorax: whereas Lungs taken out of the Thorax do
 “dilate in Vacuo, and continue so, even when Air is let into
 “the Receiver.”

IF any one is curious to know how this Air does at first insinuate itself into this Cavity, I can only refer him to the 112th and 113th Experiment in Dr. Hales's *Vegetable Statics*; where he may be informed with how very small a Force Air will pass thro' the Substance of the Lungs: And leave him afterwards to determine in his own Mind, whether it will not follow from those Experiments, that the external Air must in like manner insinuate itself into the Cavity of the Thorax, if ever that Cavity is void of Air.

EITHER this must follow, or an absolute and constant Contiguity of the whole external Surface of the Lungs to the Parts which are next them: And how far this is from being always the Case, will appear from the Experiments we shall produce in the following Pages.

LET us therefore, upon the Strength of these Experiments, conclude that there is Air within the Cavity of the Thorax, and see what share it will have in the Action of Respiration.

TO understand this clearly, let us suppose, after an Expiration is made, that the Lungs remain contracted, whilst the Cavity of the Breast enlarges to its utmost Extent, in order to make the next Inspiration. Then must the Air in the Cavity have more and more room to dilate into, and consequently press less and less forcibly upon the outward Surface of the Lungs, than it

did before. And if we now suppose the Lungs at Liberty, the external Air will immediately enter at the Wind-pipe, and equally and uniformly dilate every Part of the Lungs, till they fill so much of the Cavity as to reduce the Air without them to an Equilibrium with the Air within.

LET us, in the same manner, suppose (now an Inspiration is made) that the Lungs remain dilated, whilst the Cavity of the Breast contracts, in order to make the next Expiration. — Then must the Air within the Cavity be condensed into a smaller Compass, and consequently press with a greater Force upon the external Surface of the Lungs ; and if we now suppose the Lungs at Liberty again, they must every where be equally and uniformly compressed by this surrounding Air, till they subside into a narrower Compass, and give room to that Air to reduce itself to an Equilibrium with the Air within them : which can not be done till the same Quantity of Air is thrown out of the Lungs that was before taken in.

UPON these Suppositions, therefore, the Lungs are dilated, and contracted, by the Difference of the Pressures of the Air within and without them, occasioned by the enlarging and contracting of the Cavity of the Thorax.

NOW what has here been supposed to be done by Starts, and with a considerable Force, is in Nature performed gradually, and with the greatest Ease.

FOR as soon as the Cavity of the Breast begins to be enlarged, the Equilibrium is destroyed between the Air within, and without the Lungs ; and the instant the Difference of the Pressures is sufficient to dilate them, the Air begins to enter at the Wind-Pipe ; and ever after that, during the gradual enlarging of the Cavity, it equally and uniformly distends the Lungs, continually supplying the Space deserted by the Ribs and Diaphragm, and constantly preserving the same Difference of Pressure between it, and the Air within the Cavity, till that
Cavity

Cavity is enlarged to its greatest extent: And when it begins to diminish, the Superiority of Force begins to be on the side of the Air within the Cavity; and as soon as it becomes sufficient to squeeze together, and contract the Lungs, the Air within them begins to yield, and go out, as before it entered, at the Wind-Pipe: And thus during the whole time the Chest is contracting, will the Air without the Lungs, with the same gentle Degree of Force, equally and uniformly press upon every Part of the external Surface of the Lungs, till it has gradually forced out the same Quantity of Air which had before been inspired.

THUS the alternate and contrary Actions of Respiration are perform'd with equal Ease, by the Assistance of the Air within the Cavity: which seems to be designed, as well to prevent the Lungs from being at any time too suddenly or too forcibly dilated in Inspiration, as to press uniformly upon their whole external Surface, and equally contract every Part of them in Expiration.

THIS Way of accounting for the Action of Respiration, seems to be very strongly confirmed by an Experiment of Dr. Hales, mentioned in his *Hæmæstaticks*; and by two others, which were lately made, in order to discover what Effect letting the external Air into the Cavity of the Thorax would have upon the Action of Respiration.

Dr. Hales gives this Account of his Experiment, p. 77.
 “ I made an Incision of two Inches length between the Ribs
 “ in the Thorax of a Dog on the right side. At first opening,
 “ *the Lungs were dilated so as to fill up the Cavity of the*
 “ *Thorax*; for they pressed against the inward Orifice of the
 “ Wound, and *continued in this State for some time.* But
 “ then as *this right Lobe of the Lungs fell* gradually more
 “ and more, so the Dog *shewed more and more Uneasiness in*
 “ *breathing*; and on *dilating and contracting* the Thorax by
 “ the

“ the Action of the Diaphragm, the Air rushed briskly *in* and
 “ *out* at the Incision. But when the Orifice was covered by
 “ drawing the Skin over it, the Dog breathed in a natural
 “ way.”

THE Doctor observed, “ that on straining, the collapsed
 “ right Lobe of the Lungs would instantly dilate so vigorously,
 “ as to push the lower part of the Lobe one, two, and some-
 “ times three Inches length out thro’ the Incision.”

THE Doctor in his Observations upon this Experiment says,
 “ Hence there does not seem to be so much danger as has been
 “ imagined in the *Paracentesis*, or Incision into the Thorax,
 “ &c. for tho’ whilst the Orifice was open, this Dog breathed
 “ with difficulty; yet the left Cavity of the Breast being by
 “ means of the Mediastinum still closed, the left Lobe of the
 “ Lungs played to and fro to such a degree, that the Dog
 “ breathed enough to keep up the Circulation of the Blood
 “ for near a quarter of an Hour, as I purposely tried; and
 “ the Uneasiness in breathing not encreasing in so long a time,
 “ it is reasonable to believe that he would have lived in that
 “ manner for some Hours. But if the left Cavity of the Tho-
 “ rax had also been open at the same time, he would doubt-
 “ less have died soon.”

As there seemed nothing wanting to make this Experiment
 compleat, but actually admitting the Air into both Cavities of
 the Breast at the same time; and as I had often heard it had
 been tried, but without ever meeting with a satisfactory Ac-
 count of the Success, I was resolved on this Occasion to see it
 performed myself.

ACCORDINGLY the Experiment was tried two different
 Ways, with such different Success, that it will be proper to give
 a full Account of them both.

IN the first, we laid bare the Sternum, and part of the
 Ribs of a pretty large Dog, and applying a large Trepan, made

a wide Orifice into the Thorax. Immediately upon taking out the Piece, the Air was thrown forcibly out at the Hole, by a violent Dilatation of the Lungs; which continued for some time, and was so great, that Part of the Lungs was thrust out at the Hole. When the Lungs subsided, a Finger was introduced, and a Perforation made thro' the Mediastinum; by which means we were certain that the Air had free Ingress into both Cavities. Upon this, another violent Dilatation of the Lungs followed with such Force, as threw the Ends of both Lobes of the Lungs out at the Hole, where they continued for a while. Then the Lungs contracted, but not quite with such apparent Violence as they seemed at first to dilate with: and thus they dilated, and contracted again, and again, irregularly, and unnaturally, with less and less Force, for eight, nine, or ten times; then they subsided, and collapsed; and the Dog expired.

THE whole Time, from the Making the Orifice to the Death of the Dog, was not five Minutes; and no sooner did the violent Motions of the Lungs cease, but the Dog immediately expired.

IN the second Experiment, we introduced a long and large Trochart, together with its Canula, between the Ribs of a Dog, as near the Sternum as we could, and thrust it in so far, that it pierced the Mediastinum, and reached to the opposite Ribs. In doing this we entirely avoided hurting the Lungs themselves. Whence, by the by, it is probable that the Lungs are not continually applied closely to the inner Surface of the Thorax; for if they had been so, they must in all probability have been wounded by the Trochart, which pass'd quite across the Cavity of the Thorax.

WHEN we had proceeded so far, we could not but be surprized at the great Force that was required to keep the Trochart in: which it will be difficult to account for any otherwise, than from the Force of the Air within the Cavity, which
was

was greatly compressed by the violent dilating of the Lungs, which immediately followed upon thrusting the Trochart in. For as the Dog was thrown upon his Back, the Trochart lay above, and across the dilating Lungs; and the Force of them alone would rather have kept it faster in the Wound, than have thrust it out: But the Force of the Air, when compressed within the Cavity, must be exerted against the End of the Trochart only, and so push it directly outwards. And that this was the Case, appeared upon taking out the Trochart; for then the Canula remained very quietly in the Wound, when a Passage was opened for the compressed Air to escape. This Force, therefore, which is required to keep the Trochart in, is a Confirmation of the Opinion, that there is Air contained within the Cavity of the Breast.

THE Canula was made with Holes in the Sides; so that the Air was undoubtedly let into both Cavities of the Thorax: However, to remove all Objections that could be made, another Trochart was in like manner thrust into the other side, and passing thro' the Mediastinum, its Canula was left in, crossing the first.

As to the Motion of the Lungs themselves, there was nearly the same Appearance in both Lobes, that Dr. *Hales* described in the right Lobe only.

IMMEDIATELY upon making the Wound with the first Trochart, followed a very great and forcible Dilatation of the Breast, which was repeated now and then at very irregular Intervals of Time; to each of these succeeded as remarkable and forceable a Contraction: But it was not long before the Breast gradually subsided so much, that we began to imagine the Lungs were collapsing; and should have expected the sudden Death of the Dog, if the Motion of one of the Canulæ, which rested upon the Heart, had not shewn us that the Heart still beat regularly and strongly.

UPON this, we took out one of the Canulæ, and having somewhat enlarged the Wound, we introduced our Fingers; when we could plainly feel the whole Substance of the Lungs alternately dilate, and contract, at proper and regular Distances of Time, corresponding to the Motions of the Ribs and Diaphragm: And notwithstanding these Dilatations and Contractions were very small, the Heart beat freely, and the Pulsations in the Pulmonary Artery were plainly to be felt.

IN this manner, with one of the Canulæ in his Breast, did the Dog continue to breath for above two Hours; and was at last as likely to live as at any time in the two Hours before. So that Death is by no means the immediate Consequence of the meer Admission of Air into both Cavities of the Breast at a time.

THERE is something very remarkable in the different Successes of these two Experiments; which may serve, at least, to account for the different Opinions of Authors upon this Subject: who, on both sides, seem to speak from Experience, and refer their Readers to the Effects of live Dissections.

IT will be worth our while to examine carefully into the Circumstances of each Experiment, and see whether this Difference cannot be accounted for.

THE first Appearances, upon making the Orifices, were nearly the same in both these Experiments.

IN the first, the Lungs were so violently dilated, that the Ends of the Lobes did more than once rush out at the Wound, and continued in that state for some time.

IN the second, as the Canulæ, which were in the Breast, prevented the Lungs from being thrust out thro' the Orifices, we could only judge from the Appearances, that there was the same violent Dilatation; but the Trochart was no sooner in, than the Breast was very much dilated, and continued so for a considerable time.

AND in *Dr. Hales's* Experiment likewise, the Lungs were considerably dilated, so as to press against the inner Orifice of the Wound, and remained so for some time; and upon any straining of the Dog, the lower Part of the Lobe was violently thrown out one, two, or three Inches length at the Wound.

IN order to account for this violent Dilatation of the Lungs, as well as for the Ends of the Lobes being thrown out at the Wounds; the Pain which the Animals must necessarily have been in, whilst the Wounds were making, must be taken into Consideration. For this Pain must naturally produce an Endeavour in the Animal to express it by Crying; and Crying can no otherwise be produced, than by performing an Expiration, and at the same time contracting the Orifice of the Wind-pipe, in order to force the Air thro' a small Orifice with a proper Velocity, to form the acute Sound of Whining. The Air therefore in the Cavity must press upon the external Surface of the Lungs with considerable Force, at the same time that the Air within them is prevented from going freely out at the Wind-pipe; and consequently, they will be kept tight against the Ribs, by the Pressure of the Air within the Cavity, and at the same time be rendered stiff by the compressed Air within them. This will be doing whilst the Wound is making; and consequently, when the Wound is made, the Lungs will be seen in a dilated State, pressing against the Orifice of the Wound; and if the Animal strains with great Violence, the Air will be forced thro' the contracted Orifice of the Wind-pipe with greater Velocity; the Lungs themselves will not be so much dilated; the Air within the Cavity will press them more violently against the Ribs; and consequently, the most flexible Parts of them (which are the taper Ends of the Lobes) will be forced out at the Wounds, more or less, in proportion to the Strength and Quickness with which the Animal is straining; and the Ends of the Lobes will continue out, till the prolonged Expiration is over,

over, and no longer ; unless they should accidentally stick fast in the Wound, which has sometimes been the Case. For when the Expiration ceases, the Crying must cease with it ; an Inspiration must follow ; the Air in the Cavity must have room given it to dilate into ; and consequently, the Ends of the Lobes, (protruded only by the Force of that Air, when condensed) must return in again, and remain so till the Dog begins again to cry.

THIS I conceive to be the true Way of accounting for the first Appearances in all these Experiments.

BUT why did one of these Dogs continue alive for above two Hours ; and the other, scarce a Moment after the violent Dilatations and Contractions ceased ?

I AM apt to believe it was owing entirely to the different Sizes of the Apertures made into the Cavity of the Thorax. The Orifice, made by the Trepan, was about the Bigness of a Crown Piece : The two Orifices made by the Trocharts were not so big, taken together, as a Shilling.

NOW from what has been said before, Respiration is carried on, by the Motions of the Ribs and Diaphragm alternately giving the Superiority of Force to the Air within and without the Lungs ; consequently, so long as the Air within the Cavity can be alternately compressed and dilated, so as now to be more dense, and now more rare, than the Air within the Lungs, so long will Respiration go on.

AGREEABLY to this, in Dr. *Hales's* Experiment, whilst the Orifice was open, the Dog breathed with Difficulty ; because in Inspiration, when the Air in the Cavity should have been rarefied, the external Air rushed in thro' the Wound and prevented it ; and in Expiration, when it should have been condensed within the Breast, it rushed out at the Wound. But when the Skin was drawn over the Orifice, Respiration went on as regularly as before the Wound was made ; because

the Air within the Cavity had then a Power of dilating when the Thorax was enlarged, and must be condensed when the Thorax was contracted, exactly as in natural Respiration.

So if you suppose a small Orifice to be made on each side of the Breast; it will follow, that when the Cavity enlarges, the external Air will enter faster thro' the Wind-pipe into the Lungs, than thro' these small Orifices into the Cavity, and the Lungs will have time to dilate before the external Air can enter into the Cavity to prevent them; and, for the same Reason, upon contracting the Cavity of the Breast, and condensing the Air both within the Lungs and the Cavity, the Air has a freer Passage to escape out of the Lungs at the Wind-pipe, than out of the Cavity at the Orifices; and consequently, in this Case, the Action of Respiration will be performed, tho' not so perfectly as in a natural State; and the smaller these Apertures are in proportion to that of the Wind-pipe, the more like the natural will the disturbed Respiration be.

So that probably, by this way of Reasoning, the Death of the Dog in the first Experiment was owing to the Size of the Aperture; which was so large, that the dilating and contracting of the Thorax could produce no Alteration in the Density of the Air in the Cavity, the Communication being too great and too sudden with the open Air.

WHEREAS, in the other Experiment, the Apertures were so small, that the free Passage of the Air thro' them was retarded; and consequently, some Alteration, tho' but an inconsiderable one, was made in the Density of the Air within the Cavity, by the Motion of the Ribs and Diaphragm; and some sort of Respiration was accordingly kept up.

I ONLY offer this as an Attempt to account for this remarkable Difference in the Events of these Experiments, not having had an Opportunity, or indeed any Inclination, to try more of these cruel Experiments, in order to be fully satisfied that this was really the Case.

UPON

UPON the Whole, therefore, may we not conclude,

1. THAT the Actions of the external Ranges of Fibres in the Intercoſtal Muſcles raiſe the Ribs and Sternum, both upwards and forwards ?

2. THAT the Diaphragm, at the ſame time, by the Action of its Muſcular Fibres, pushes the Contents of the Abdomen downwards and forwards ?

3. THAT the Cavity of the Thorax is by both theſe Motions conſiderably enlarged ?

4. THAT the enlarging the Cavity of the Thorax is not barely deſigned for the containing the inflated Lungs, which in common Reſpiration do not dilate to the utmoſt they are capable of ? But,

5. THAT the great Uſe of this enlarging the Cavity of the Thorax is to give room to the encloded Air to dilate, by which its Elasticity, and conſequently, its Preſſure upon the external Surface of the Lungs, is diminished ?

6. THAT whiſt the Cavity of the Thorax is thus enlarging, the Lungs are gradually and gently dilated with a Force equal to the Difference of the Preſſures of the Air within, and without them ?

7. THAT immediately upon the Ceſſation of the Actions of the Diaphragm, and the external Ranges; the internal Ranges of Fibres, aſſiſted by the *Serratus Poſticus* inferior, begin to act and depreſs the Ribs and Sternum ?

8. THAT the Abdominal Muſcles and the external Air do, at the ſame time, by the Intervention of the Contents of the Abdomen, ſqueeze up the Diaphragm into the Thorax again ?

9. THAT the Conſequence of this, is diminiſhing the Cavity of the Thorax, and compreſſing the Air within it; and conſequently, encreasing its Preſſure upon the external Surface of the Lungs ?

10. AND lastly, that the Air within the Lungs having nothing to keep it in, must yield and give way; and consequently, the Lungs will, during the Depressing of the Ribs, be gradually, gently, and uniformly compressed; and the Air thrown out again with a Force equal to the Difference of the Pressures of the Air within and without them?


THUS have I endeavoured to explain the Action of Respiration, and the Mechanism by which it is performed; and I have chosen to be so particular in enumerating the Steps taken in the Performance of it, that I may with the greater Distinctness proceed to examine the different Opinions of Authors concerning the Use of Respiration in the Animal Oeconomy, which is the Subject of my next Discourse.



LECTURE II.

OF THE

USE *of* RESPIRATION *in the* ANIMAL OECONOMY.

OON after the Circulation of the Blood was discovered, and the Certainty of it established beyond dispute, it was readily allowed by almost every one, that the Health, Strength, and Nourishment of the Body was owing to the Blood's being duly and constantly circulated thro' every Part of it; and that in whatever Way those Parts were nourished, the Nourishment itself was conveyed by the Blood: and consequently, that the Blood must, in a healthy State of the Body, be so constituted as to contain the Particles designed by Nature for Nutrition; and at the same time to preserve itself in such a Degree of Fluidity, as would enable it to pass thro' every the minutest Vessel.

THIS led the Way to an Enquiry, How this particular Constitution of the Blood was so duly kept up whilst it was in the Body, which every one knew it would immediately lose upon being taken out of it?

THE

THE Lungs were soon fixed upon as the most likely of all the Parts of the Body for performing this necessary Office; and not without very good Reason. For, besides that it followed from the Make of the Heart, and the Distribution of the Pulmonary Veins and Artery, that no Portion of Blood, how minute soever, could perform two Circulations, without passing thro' the Lungs; there was an obvious Difference in the Colour of the Blood after it had pass'd thro' the Lungs, from the Colour of it before: Whence it was reasonable to conclude, that something very material happened to it in that Viscus.

THE Difference of Colours in the Blood in the Veins and Arteries had been observed long before the Circulation was thought of; and it was accordingly divided into Venal, and Arterial Blood: and these were looked upon then as different Fluids, performing different Offices in the Animal Oeconomy.

BUT when the Course of the Circulation was well understood, and it was known for certain that the Fluid, both in the Veins, and Arteries, was one and the same Blood continually visiting all Parts of the Body; that every Portion of it, after it had passed the minutest Vessels, returned to the Heart in the *Veins* of a very different Colour from what it had in the *Arteries*; that it retained this new Colour even till after it had passed the Heart, and the Pulmonary Artery had conveyed it to the Lungs; and lastly, that it no sooner came out of the Lungs, than it appeared in the Pulmonary Vein restored again to the Colour it was of in the Arteries: it was thought reasonable to conclude in general, that the Constitution, as well as the Colour, of the Blood was different before from what it was after it had passed the Lungs; that the Arterial Blood did more particularly contain the proper Nourishment which was to be convey'd by the Circulation to every Part of the Body; and that whatever was wanting in the Venal Blood for the Purposes of Life, whether from a loss of Nutritious

tious Particles, or some Variation in the Degree of its Fluidity, was given to it in its passage thro' the Lungs, where it so plainly recover'd its Arterial Complexion.

AND as every one was then busy in making Enquiries into all Parts of the Animal Oeconomy; it was not long before this Opinion received a very strong Confirmation: for the very Vessels were found, by which those Parts of our Food, which are designed for the Nourishment of the Body, are taken up and conveyed into the Blood, under the Form of a milky Fluid, since known by the Name of *Chyle*.

FROM this Discovery it appeared, that the *Chyle*, after it is duly prepared and digested, is almost continually pressed thro' the Thoracick Duct, and lifting up the Valves in the Subclavian Vein, is forced in small Quantities into it; whence, following the Course of the Veins, it is carried together with the Blood which returns from the superior Parts of the Body into the *Sinus Venosus*: and here meeting with the rest of the Blood which returns from the inferior Parts of the Body, it is together with them both conveyed into the Heart, and thence into the Pulmonary Artery.

HENCE it was evident, that there was continually passing into the Lungs a Portion of Venal Blood, with a small Share of *Chyle*, not yet duly and intimately mixed with it; and as there was continually passing out of them a Portion of Arterial Blood, differing very visibly both from the *Chyle* and Venal Blood; it was very reasonably imagined, that this Difference arose from the Venal Blood's being more duly blended together, more intimately mixed with this Supply of *Chyle*, and so altered in its Constitution, whilst it was passing thro' the Lungs, as to be more fitted for the Offices of the Circulation: And hence it was concluded, that the Lungs were not only so situated as to receive each Portion of Blood at its return to the Heart, after every Circulation, and together with it what *Chyle*

was ready prepared and digested; but so constructed likewise, as intimately and duly to mix them together into one uniform Fluid, of such a Degree of Fluidity as enabled it to pass the minutest Vessels in the Body.

AND as a constant Supply of fresh Air was, by the alternate Actions of Inspiration and Expiration, admitted into the innermost Recesses of the Lungs, whilst these Alterations were making in the Blood within them; which Supply of fresh Air was known to be absolutely necessary to Life: it was imagined that some vivifying Aura was imbibed by the Blood in its Passage thro' the Lungs, without which it would be absolutely unfit for the more secret Purposes of Life.

THESE Considerations naturally led the Way to still farther Enquiries into the particular Mechanism of the Lungs themselves, and the Manner in which so advantageous and necessary an Alteration was made in the Blood whilst it is passing thro' them.

IN order to understand what has been said upon a Subject of so nice a Nature, it will be necessary to give a Description of the Make of the Lungs; but not so minute a one as might at first be imagined: It will be sufficient for our Purpose to consider them as consisting only of Air-Vessels, Arteries, and Veins; by the first of which the external Air is alternately admitted into, and thrown out of their very inmost Recesses; and by the latter, the whole Mass of Blood is continually circulating thro' their minutest Vessels.

THE external Air is received by the Trachea Arteria; which, as soon as it enters the Lungs, dividing into the Bronchia, conveys it to the different Lobes which lie on each side the Mediastinum. These Bronchia are divided and subdivided insensibly into smaller, and still smaller Branches on each side, and constitute the Lobes. Each of these Lobes may be subdivided into Lobules; and in these smallest Lobules the Air-Vessels terminate in Vesicles, which communicate one with another.

So

So that thro' the Bronchia the Air is admitted into the Vesicular Cavities of every the minutest Lobule.

To give a proper Notion of the Blood Vessels, it will be sufficient to observe, that the Pulmonary Artery enters the Lungs nearly where the Trachea Arteria begins to divide; and dividing immediately into two, follows the Air-Vessels in all their Progress thro' the Lungs, dividing and subdividing nearly as they do, till at last it ends in a surprisngly-minute Network of Capillary Branches, inosculating with one another, and distributed all over the Sides of the Vesicles described above.

THE Blood brought by this Artery, and distributed thus thro' every Part of the Lungs, is taken up again by the minutest Branches of the Pulmonary Veins: which continually uniting with one another, as they carry it back to the Heart, grow gradually larger and larger; are constantly situated close by the Arteries and Bronchia; and end at last in the four short Veins which go out of the Lungs nearly where the Artery enters. *Vide Eustach. Tab. 27. Fig. 13.*

FROM this Construction of the Blood-Vessels, it most undoubtedly follows, that the Venal Blood, together with the Chyle, which is brought in one large Vessel into the Lungs, must pass thro' the very minute Vessels, which are distributed over the Sides of the Vesicles, before it can be taken up by the Veins and returned to the Heart; the Consequence of which is, being first divided into the minutest Streams, and afterwards gradually mixed together again.

AND from the Distribution of the Air-Vessels of the Lungs, it follows, that the Air must be continually admitted into the Cavity of these Vesicles; by which Means it is brought within less than the thousandth Part of an Inch of being in immediate Contact with the Blood, whilst it is divided into the minutest Streams; there being nothing between but the excessively fine Sides of perhaps the minutest Vessels in the whole Body.

AND from the alternate Actions of Inspiration and Expiration, it will follow, that the Surfaces of these Vesicles, together with the Blood-Vessels, which are distributed upon them, must be alternately pressed upon by the Air within and without them, and consequently be in continual Motion.

LET us therefore carefully and separately examine into the Effects which are likely to follow, 1. from the Venal Blood and *Chyle's* being thus divided into exceedingly minute Streams, and afterward reunited again into one ; 2. from the different Pressures which it is alternately exposed to in the minute Blood-Vessels ; and lastly, from the Motion of these Blood-Vessels, which is the Consequence of this different Pressure ; and see whether they are sufficient to account for the remarkable Difference which is found in the Blood when it is taken up by the Veins and united again into larger Streams.

FIRST, the separating the Blood into the minutest Streams, and uniting it again into a large one, is no more than what is performed exactly in the same manner to the whole Mass of Blood in every Circulation, by the whole Set of Arteries and Veins in the Body ; and to Part of it at a time in almost every particular Viscus : in one Case for the secret Work of Nutrition, and in the other for the better carrying on the Secretion that is to be made in every particular Viscus.

BUT in both these Cases, it is the Arterial Blood which is thus divided into the minutest Streams ; and after every such Division, reuniting its Streams, it constantly returns of that Constitution which denominates it Venal Blood.

SINCE then we find that Arterial Blood is changed into Venal, as well as Venal into Arterial, after having been separated into minute Streams, and united again ; this Consideration alone will be of little or no Service in our Enquiries.

LET us, therefore, next examine what the Blood undergoes in passing thro' the Lungs from the Pressure of the Air upon the Sides of the Vessels thro' which it circulates.

FROM

FROM what was said in my first Discourse, it will be easy to understand, that at every Expiration the Air is thrown out of the Lungs by the Motion of the Sides of the Vesicles; and that in order to do this, they must sustain and overcome the Weight of so much Air as they remove. So that before we can determine what the Blood undergoes in circulating among these Vesicles, whilst they are thus throwing out the Air, we must first see what this Pressure is which the Sides of the Vesicles must sustain.

IF for this Purpose we consult the Writers of the best Character for their Knowledge, not only in the Anatomy of the Parts, but even in Philosophy and Mathematics; we shall find them so widely differing in their Accounts, that one unacquainted with their Works would rather think they were guessing at the Truth, than that each of their Opinions was backed with Mathematical Calculations.

ONE assures us, that the Pressure of Air overcome in gentle and ordinary Respiration, is equivalent to the Weight of fourteen Thousand Pounds; another contents himself with a bare Hundred; and a third makes it so inconsiderable, he can hardly find a known Pressure insignificant enough to compare it to; whilst all the Three appeal to Mathematical Demonstration for the Truth of what they assert.

BUT whoever will examine the different Methods in which these Gentlemen form their Calculations, will readily give the Preference to the Last: He will never find him attempting to build, till he has got a sure and solid Foundation prepared for him by Nature; and accordingly, the Result of his Calculation is agreeable to the Ease with which Nature carries on all her most constant Works.

THE *Impetus* (says this Author) which the internal Surface of the Lungs sustains in a common Respiration, is less than the Motion of the gentlest Dew descending from the Sky, being
equal

equal to the Motion of a Column of Water (whose Base is the internal Surface of the Lungs, and whose Height is but the $\frac{1}{70000}$ Part of an Inch) moving with a Velocity no greater than what would carry it thro' an Inch in a Second of Time.

THAT this is the Truth, no one will doubt, if he reflects upon the Ease with which Respiration is commonly performed; or if he considers attentively the Mechanism of the Parts, as we explained it above.

CONSIDER the Make of the Vesicles, how thin and pliable they are; how they are situated in the Lungs; what free Access the external Air has to them; and that they are all enclosed by the external Coat of the Lungs: Consider that this external Coat is surrounded every where by the Portion of Air contained within the moveable Walls of the Thorax; follow in your Minds the Motions of the Breast in Inspiration and Expiration; and you will readily see that the internal Surface of these Vesicles cannot suffer more from the Pressure of the Air, than the Surface of your Hands, when you move them to and fro with the same gentle Velocity.

IN Inspiration, the Ribs are gradually moved upwards, and the Diaphragm gradually pushed out; the Air within the Cavity would therefore gradually have more and more Room allowed it to dilate into, if the Air within the Lungs did not as gradually dilate the Vesicles and swell the Lungs, so as always to keep the Air in the Cavity very nearly of the same Degree of Density: So that little or no Alteration is made in the Pressure of the Air, either within or without the Lungs; only more Air is suffered to enter the Lungs: but Air does not press in proportion to its Quantity, provided the Space enlarges with the Quantity, as here it is permitted to do.

FOR the same Reason, in Expiration, as the Cavity of the Thorax is gradually diminished, the Air is gradually pushed out of the Lungs; but the Pressure is no where much greater than it was before.

INDEED

INDEED if the Air was prevented from going out of the Lungs, there would gradually, as the Breast subsided, be more and more Pressure upon both the internal and external Surface of the Lungs, because the Air both within and without the Lungs must of Consequence be compressed ; and as the Orifice of the Wind-pipe is but small, if the Cavity of the Breast was greatly to be diminished at once, there would arise a considerable Difference of Pressure upon the Lungs ; because the Air would be compressed faster than it would have Power to dilate : But as the Cavity of the Breast does, in easy Respiration, gradually enlarge and contract, and consequently allow Time for the Air to pass freely in and out thro' the Wind-pipe ; the Pressure of the Air upon the Vesicles, or the Action of the Vesicles upon the Air, is no more than what every Part of the Body undergoes, that is in the same Degree of Motion.

FOR any Advantage therefore which can arise to the Blood from the Pressure of the Air alone upon the Vessels in which it circulates, it equally enjoys it in every other Part of the Body, as well as in the Lungs.

WE are next to enquire, What Degree of Motion is given to the Sides of the Vesicles by the alternate Motions of Respiration, and what Effect it will have on the Blood ?

INDEED if we argue from the violent Motions of the Lungs, which happen upon opening the Breasts of living Animals, where they are now stretched out with such Force, as almost to crack the Vessels which compose them ; and now so contracted and squeezed together, that one would never expect to see them dilated again ; we might, perhaps, be led to believe the Motion of the Vesicles worth our Consideration : But even in this Case, the Blood would not be more acted upon by the Sides of its Vessels, than it must be in the minute Vessels of the Muscular Parts of the Body in hard Labour or violent Exercise ; and yet the Blood returning in the Veins after such
Muscu-

Muscular Action, has no more of the Arterial Constitution, than at any other time. It could not therefore be concluded, that the Arterial Constitution accrues to the Blood from the irregular Motions of the Sides of the Vesicles, even tho' there was always such a considerable Motion given to them in Respiration.

BUT if we consider how easily Respiration is performed in Sleep, when the Body is most recruited, and the most secret Offices are carrying on; how gently, and yet how freely, the Air is respired; and besides this, how much Air is constantly retained within the Lungs: we shall find Reason to conclude, that the Vesicles of the Lungs are at all times considerably expanded, tho' they are more so in Inspiration, and less in Expiration.

IF likewise we reflect upon what was delivered above, both from Calculation and the obvious Mechanism of the Parts, concerning the Smallness of the *Impetus* of the internal Surface of the Lungs, and compare it with the Time an easy Expiration is performing; we shall be very well satisfied how inconsiderable the Velocity of the Sides of the Vesicles is in ordinary Respiration.

So that it seems probable, that the Blood-Vessels, which are distributed about the Coats of these Vesicles, receive pretty nearly the same Degree of Motion from free and easy Respiration, that the Blood-Vessels about the Coats of the Viscera do from their Peristaltick Motion; and if this Degree of Motion is of any considerable Use in arterializing Venal Blood, why does it not appear in the Blood which returns from the Viscera by its having some Degree at least of this Arterial Constitution?

UPON the Whole, therefore, does it appear that any thing more happens to the Blood, either from the Minuteness of the Vessels thro' which it circulates in the Lungs, or from the Pressure of the Air upon those Vessels, or from the Motion of their Sides,

Sides, than what happens to it in almost every other Part of the Body?

OR, Is there any more Reason to suppose, that the red Globules of the Blood are (if I may be allowed the Expression) *taken Measure of* in the Lungs, and squeezed down to a proper Size to fit the minute Vessels of the Body, than that in passing the minute Vessels of the Body they are prepared to circulate thro' the Lungs; especially since the Blood circulates thro' every Part of a Fœtus, before it is permitted to pass thro' its Lungs?

YET great Notice is taken of these Globules, and great Regard paid to the Pressure of the Air upon them, and the Motions of the Sides of the Vessels thro' which they circulate; and the Consequences of them are supposed by some to be very material: For hence, say they, the Blood can, at no two Instants of Time, nor in any two Points of the Lungs, be equally pressed upon; and consequently, by this Difference of Pressure, and the great Velocity with which the Blood circulates thro' the minute Blood Vessels, which are themselves in perpetual Motion; The old, worn, and broken Globules are *squeezed together, and formed anew, rubbed down, and ground, and turned and twisted into such Shapes*, as suits them best (according to the favourite Hypothesis) to the future Offices of the Circulation.

IT will, therefore, be worth while to remind you of an Experiment of Dr. *Lower's*; from which it will very plainly appear, that neither this alternate Motion, nor this Difference of Pressure, is at all necessary to the Production of the Arterial Constitution of the Blood.

THE Doctor contrived a Way, first by making small Incisions thro' the outward Coat of the Lungs of a living Animal, and then by blowing a continual Blast of Air in at the Wind-pipe, to keep the Lungs continually distended with fresh Air; and whilst they were thus without Motion, and consequently whilst

the Blood circulated without any different Degrees of Pressure, he opened the Pulmonary Vein, and found the Blood returning in it, as truly Arterial Blood as what used to be found in that Vein when the Lungs were ever so violently in Motion.

BUT notwithstanding it appears, that the Action of the minute Vessels in the Lungs is in itself the same with the Action of the minute Vessels in the Body; yet if we reflect upon the different Natures of the Venal and Arterial Blood before they undergo this Action; if we consider the different Discharges which are made from them, whilst they are undergoing it; and after they have gone thro' it, if we compare the Compactness, Elasticity, and continued Pulsation of the Arteries which receive the Blood at its Return from the Lungs, and convey it to the minute Vessels of the Body, with the yielding, lax, and inactive Make of the Veins, which take up the reflux Blood from the minute Vessels of the Body, and return it again to the Heart; we shall not be at all surpris'd, that one and the same Action should contribute to the different Alterations in the Blood we are now enquiring into.

IF, besides this, we find that the Blood does, in its Passage thro' the Lungs, receive a very considerable Supply of those active and nutritious Particles which it loses in circulating thro' the Body, we shall be at no great Loss to determine for what Uses they were principally designed in the Animal Oeconomy.

1st. As to the different Natures of Venal and Arterial Blood, I shall consider them only in general, and observe, that the Arterial Blood is intimately, uniformly, and duly blended together, so as to form a Fluid, suited to the Offices of the Circulation; and that the Venal Blood is not perfectly so, but has lost some of that peculiar Constitution, and is approaching to that disunited State which it soon falls into when it is taken out of the Veins and left to itself in any Vessel without Motion.

CONSEQUENTLY, tho' the whole Mass of Blood, Venal as well as Arterial, is made up of a Number of Fluids, all of different Natures, and is therefore a very heterogeneous Fluid; yet when the Arterial Blood is compared with the Venal, it may allowably enough be termed Homogeneous: because every Portion of Arterial Blood is nearly of the same Nature with that which succeeds, or that which goes before it; which is not true of the Venal Blood.

WHAT still makes the Fluid which circulates thro' the Lungs more heterogeneous is, that the *Chyle* (which is itself an heterogeneous Fluid) is just before squeezed into the Venal Blood, without being duly and intimately mixed with it.

THE Fluid, therefore, which is to be divided into very minute Streams in its Passage thro' the Lungs, composed thus of *Chyle* and Venal Blood, must, of consequence, be very heterogeneous; whereas That which is to be served in the same manner in the minute Vessels of the Body, is in this Case to be looked upon as homogeneous.

THIS is the first remarkable Difference worth our Consideration.

IN the next Place, we are to consider the Discharges made from these different Fluids, whilst they are thus separated into minute Streams.

THE Discharges made from the Arterial Blood may be reduced to these general Heads:

1. WHATEVER is separated from the Blood in the Office of Nutrition;

2. WHATEVER passes off by insensible Perspiration at the Surface of the Body;

3. WHATEVER in like manner transudes thro' the Vessels into the Cavities of the Body; and

4. WHATEVER is secreted from it in any Gland or Viscus, is taken from the Arterial Blood.

THE

THE first of these Discharges is evidently of such Particles as are of the most Advantage to the Health of the Body; and as they are the most attractive, they are, without doubt, such as are most serviceable in keeping up the Arterial Constitution.

As to the Second and Third, tho' they are chiefly of such Particles as are recrementitious, yet, together with these, there must escape some of the nutritious Particles; and consequently, Part of these Discharges must be of disservice, and impair the Constitution of the remaining Blood.

AND as to the Secretions in general, which are made from the Arterial Blood, the same is more remarkably true, both with regard to what nutritious Particles go off with them, and with regard to the Service most of these Secretions are afterwards of in supplying the Food with such Qualities as make it more readily mix and unite with the Venal Blood, to form it again into Arterial Blood: For the same Reason, therefore, that these Secretions are afterwards of Service in reducing the disunited Venal Blood and *Chyle* again to the proper Arterial Constitution, the Loss of them must be of Disservice to the Arterial Blood, and impair its homogeneous Constitution; and accordingly we find the Arterial Blood, after every Secretion, even when the Parts secreted are excrementitious, brought back in the Veins, as of no farther Service, till it has again been circulated thro' the Lungs.

So that, in general, the Discharges made from the Arterial Blood, tho' they all of them promote the Welfare of the whole Body, are of disservice to the Blood itself, as to its Arterial Constitution, *i. e.* they do all of them, in some Degree or other, tend to impair and render it Venal.

ON the contrary, we shall find that the Discharge made from the Venal Blood and *Chyle*, in their Passage thro' the Lungs, is most beneficial to the Blood, and greatly promotes the Recovery of its Arterial Constitution.

THIS

THIS will be very plain, if we consider it in the following Manner:

UPON examining the Weight of what we eat and drink, and comparing it with the Weight of what we discharge by Stool and Urine, we find that much the greater Part of our Food goes off by insensible Perspiration, *i. e.* passes off thro' the minute Pores of the Body, and is taken up by the Air in the Form of so subtle a Fluid as to escape our Observation.

IN this Account therefore of insensible Respiration, is included whatever is taken up by the Air, as well in the Lungs as at the Surface of the Body.

WE have already observed, that the Air has a free Admittance into the Vesicular Cavities of every the minutest Lobule in the Lungs; and it likewise appears, from the most accurate Estimate that has yet been made, or perhaps that the Nature of the Thing will admit of, that the internal Surfaces of all the Vesicles taken together, to which the Air has this constant and free Admission, amount to near ten times the Surface of the whole Body.

As it happens that whenever Perspiration is much encreased, we find a watery Fluid condensed upon the Surface of the Body; and whenever we open any Part of an Animal, we find it moist, and a vapoury Steam arising from it, at the same time that the red Parts of the Blood are carefully preserved within the Vessels; we might safely enough conclude, that the exceeding fine Coats of the minute Vessels in the Lungs will, in the same manner, suffer these watry Parts of the Blood and *Chyle* to escape thro' their Pores, without letting the more oily and attractive Particles, which compose the red Globules, go off with them.

AND as the Expanse of Air to which the Blood is here exposed is so much greater than that at the external Surface of the Skin, we might too conclude, that the Discharge here must be considerably greater than at the Skin.

BUT

BUT as Experiments are much more convincing than the most subtle Arguments, I shall transcribe a few from Dr. *Hales's* *Hæmæstaticks* (Page 73—77) by which we shall be enabled to form some Judgment, both of the Nature and Quantity of this Discharge.

“ I FIX'D (says Dr. *Hales*) a Glass Tube to the Pulmonary Artery of a Calf's Lungs, and then thro' a Funnel poured warm Water into it ; then with a large Pair of Bellows fix'd to the Wind-pipe, I alternately dilated the Lungs, to try if by that Means the Water would pass into the Pulmonary Vein ; but I soon found myself disappointed, for the Water flowed so freely from the Capillary Arteries thro' the Tunicles of the Vesicles into the Vesicles themselves, and thence into the Bronchia, as to flow plentifully thro' the Wind-pipe, when it hung down in a depending Posture.”

“ AT first I suspected that the Force of the Water, which was four Feet high in the Tube affixed to the Artery, might have burst the thin Blood-Vessels ; but I found it the same in several Tryals on the fresh warm Lungs of Sheep, Oxen, and Calves, even when the perpendicular Height of the Water in the Tube was less than a Foot ; and doubtless the Force, with which the Blood is thrown into the Lungs by the right Ventricle of the Heart, is greater than this.”

“ AND that so small a Force of Water could not burst the Blood-Vessels, I was assured by the following Experiment, viz. I dissolved four Ounces of *Nitre* in a Pint of hot Water, into which Water there flowed from the cut Throat of a Calf, a Quart and a Quarter of a Pint of Blood, which was kept in a diluted State by the nitrated Water. Having then fixed a Tube, which was two Feet long to the Pulmonary Artery of the above-mentioned Calf's Lungs, I poured gradually into the Tube, of the nitrated Blood, as much as the Artery and its Ramifications would contain, which was

“ near

“ near a Quart, none passing, that I could perceive, into the Pulmonary Vein.”

“ THE Lungs were much dilated, and looked very red ; but notwithstanding the perpendicular Height of the Blood in the Tube was two Feet, yet no Blood passed thro’ the Tunicles of the Vesicles into the Vesicles and Bronchia ; for when the Wind-pipe was held downwards, nothing flowed out but a white Froth : A plain Proof, that when the Water was less than a Foot perpendicular in Height in the foregoing Experiments, it did not forcibly break thro’ the Blood-Vessels, but must pass thro’ Pores, which were too fine for the Globules of nitrated Blood to pass.”

“ WHEN I cut a Slash into the Substance of the Lungs, the nitrated Blood flowed freely out.”

“ AND that the Capillary Vessels are not burst by the Force of the Water, seems further probable from hence, *viz.* I fixed a Tube, five Feet long, to the Pulmonary Vein of a Hog’s Lungs, and poured in warm Water, which neither flowed into the Pulmonary Arteries, nor among the Bronchia : an Argument that this Force did not burst these Veins ; which, some Anatomists say, have no Valves in them.”

“ WHEN I fixed the Tube to the Wind-pipe of those Lungs, and poured in Water, it passed thro’ the Bronchia, and ran out of the Orifice of the Pulmonary Artery ; but not above one fifth so fast, as when its Course was the reverse, *viz.* from the Pulmonary Artery to the Bronchia ; in which Case it run at the Rate of a Pint in a Minute.”

“ YET when Air was blown into the Cavity of the Lungs thro’ the Wind-pipe, none passed thence, either into the Pulmonary Artery or Vein.”

“ ANOTHER time I tried also, whether the thin Serum of a Hog’s Blood would pass from the Pulmonary Arteries thro’ the corresponding Veins of the Lungs of the same Hog ;
“ which

“ which Lungs were kept warm with Water : the Serum passed most freely thro’ into the Bronchia, but not into the Veins.”

THUS far Dr. *Hales*.—Now from these Experiments it will follow, that what is taken up by the Air in the Lungs is the serous Part of the Venal Blood, and the watry Part of the *Chyle*, which is in each of them in too great a Quantity, to be proper for constituting Arterial Blood ; but that neither the Globular and red Part, which remains unaltered in the Venal Blood, and is still fit to enter the Composition of Arterial Blood, nor the common elastick Air we breath, is suffered to pass thro’ the Coats of the Vessels.

THE Discharge, therefore, which is made from the Venal Blood and *Chyle*, is such as is plainly serviceable to the rendering them Arterial Blood.

As to the Quantity of this Discharge, it appears by another Experiment of Dr. *Hales*’s, (Page 323) to which I refer my Reader, “ that the Quantity of Moisture carried off by Respiration in twenty-four Hours, amounts to 1,39 Pound ; ” which compared with what is, at an Average, supposed to be perspired in that time, is $\frac{7}{10}$ of the Whole at least.

THIS Difference, therefore, in the Discharges made from the Venal and Arterial Blood, whilst they undergo the Action of the minute Vessels of the Body, is likewise worth our considering.

3dly, ANOTHER Consideration of great Importance to our present Enquiry is, the Supply which the Venal Blood and *Chyle* receive in their Passage thro’ the Lungs.

FROM the many Experiments which Dr. *Hales* contrived to discover the more hidden Properties of the Air, it is very evident, that That Fluid is absorbed and taken into the very Substance of all the other Bodies, whether solid or fluid, and whether they are of the Animal, Vegetable, or even the most solid of the Mineral Tribe : That after it is thus taken into them,

them, it no longer retains its elastick Quality, but adheres with the strongest Attraction to their component Particles; but that notwithstanding this, upon the Application of Fire, or upon the Action of any dissolving Menstruum, it is always ready to resume its Elasticity: and is consequently, at one time, as serviceable in preserving the Cohæsion of the Parts, as at another time it is active in promoting their Dissolution, by raising too great a Degree of Heat, or producing too violent a Fermentation.

THE Blood in particular, upon being examined by Chemical Experiments, yielded a great Quantity of Air, which before lay inactive within it, and which it must certainly have acquired within the Body of the Animal from which it was taken.

THIS naturally led him to try experimentally, Whether this Air passes into the Blood with the Aliment only, with which it must undoubtedly be mixed, or is any where immediately taken up from the external Air.

HE soon found very good Proof, that a great Quantity of elastick Air was destroyed in Breathing; and tho' it was no easy thing to determine exactly the Quantity, yet he contrived a Way of doing it with tolerable Accuracy.

THE Result of his Experiment was, that in 24 Hours, when the Air is fresh, a hundred Grains of Air are absorbed in common Respiration.

“ BUT (says the Doctor) tho' this be not looked upon as a
 “ very exact Estimate, it must still be allowed, that some of
 “ the Elasticity of the Air, which is inspired, is destroyed, and
 “ that chiefly among the Vesicles, where it is mostly loaded
 “ with Vapours; whence, probably, some of it is conveyed to
 “ the Blood, which we see is by an admirable Contrivance
 “ there spread into a vast Expanse, commensurate to a very
 “ large Surface of Air, from which it is parted by very thin
 “ Partitions; so very thin, as thereby probably to admit the

G “ Blood

“ Blood and Air-Particles (which are there continually changing from an elastick to a strongly-attracting State) within the Reach of each other’s Attraction ; whereby a continued Succession of fresh Air may be absorbed by the Blood.”

Now, if we once allow, that the Air-Particles are taken into the Mass of Blood, we must at the same time suppose them to be as ready to resume their elastick State, and as active in producing Warmth and Heat, whenever the Blood is briskly agitated in the Vessels of the Body, as they are known to be in any other Substances whatever ; and for the same Reason, whilst they are undisturbed, to be as serviceable in encreasing the Cohæsion of the Parts they are near, whether solid or fluid.

WE may therefore reasonably conclude, that the Venal Blood and *Chyle* is supplied, in their Passage thro’ the Lungs, with a Quantity of active Particles from the Air.

THE Arterial Blood, on the contrary, does no where, that we know of, receive any such Supply.

THESE are the obvious and remarkable Differences we find upon comparing the Condition of the Blood, whilst it is changing from Arterial to Venal, with its Condition whilst it becomes Arterial again ; and from these Differences, together with the different Natures and Makes of the Vessels thro’ which it circulates, after these Changes are begun, it will be easy to form a general Notion how the peculiar Constitution of the Blood is perpetually preserved within the Body, whilst in Health, and what Service the Lungs are of towards it.

IN order to this, it must be considered in general, that heterogeneous Fluids will retain their peculiar Degrees of Fluidity, as long as their component Particles are prevented, either from separating, and afterwards uniting again into different Combinations, by a proper Degree of Heat and Motion, or from flying off, by being enclosed in proper Vessels.

AND

AND on the contrary, that they will soon lose these Degrees of Fluidity, when some of their Particles are suffered to evaporate, or fly off, and the rest are left to themselves without Heat or Motion ; whence it will follow, that the longer this remaining Fluid is left to itself, and the less the Heat and Motion is to which it is exposed, the more will it degenerate from its former Constitution.

IF now we take a View of the Arterial Blood, just as it arrives at the small Vessels of any Part of the Body, and follow it in its Course thro' all the Vessels, to its Return to the Heart and Lungs again, we shall find, that at its Entrance into these minute Vessels (tho' it is undoubtedly a very heterogeneous Fluid, composed of a Number of Fluids of different Natures, yet they are all so intimately, uniformly, and duly blended together, that) every succeeding Portion of it is of the same Nature with the Portion that goes before it ; but that when it arrives at the Heart, its component Fluids are not so blended together ; different and improper Combinations are beginning ; and the Whole is approaching to that disunited State which it soon falls into when taken out of the Body : and, consequently, that unless this disadvantageous Alteration in the Constitution of the Blood be corrected at every Circulation, almost as soon as it is begun, it would not be long before it become highly improper for the Offices of the Circulation.

THIS will be evident, if we consider, that in its Progress thro' these minute Vessels, the most nutritious, and consequently the most attractive Particles, are separated from it in the Office of Nutrition ; that other Particles fly off from it in insensible Perspiration ; that in some Places larger Discharges are made from it in Secretion ; and that the remaining Fluid is separated into very numerous and minute Streams, which do not unite again till the Blood is brought into one or other of the large Veins, which brings it back to the Heart again.

AND if it be farther considered, that these large Veins are yielding, laxe, inactive Vessels, which continually grow wider and wider, and are of a considerable length, we may conclude, that the Arterial Blood, like all other heterogeneous Fluids, must lose its peculiar Constitution, both on Account of the most attractive Parts being suffered to escape by Perspiration and Secretion, or being left behind in Nutrition; and on Account of the remaining Part being for a considerable time, and in a great Degree, left to itself in large inactive Vessels, with little or no Motion; by which the different sorts of Fluids, which compose the reflux Blood, have liberty given them to separate into different and improper Combinations.

So that the Blood begins to lose its Arterial Constitution in the minute Vessels of the Body, and grows more and more depraved the nearer it advances towards the Heart; and when it arrives at it, it is the most Venal it is capable of becoming in that particular Circulation.

LET us now, in the same manner, take a View of the reflux Blood at its Entrance into the Lungs, and follow it in its Course back to the Heart, and thence thro' the Arteries to the minute Vessels of the Body; and we shall find,

1. THAT it receives at the Heart, just before it enters the Lungs, a Supply of *Chyle*.

2. THAT this *Chyle* is itself a very heterogeneous Fluid, consisting of such Particles as are very evidently designed by Nature for the Nourishment of the Body, blended and mixed with a large Quantity of thin, watery Fluid, by the Intervention of the Saliva, Bile, and Pancreatic Juice.

3. THAT this *Chyle* is not here intimately and duly mixed with the Blood; neither does it continually or equally flow into it; and consequently,

4. THE succeeding Portions of Blood and *Chyle*, which follow each other into the Lungs, are not of one and the same Constitution.

5. THAT

5. THAT these different Portions of Blood and *Chyle* are each of them separated into very numerous and very minute Streams, by the Vessels which are distributed upon the Coats of the Vesicles.

6. THAT by the Inosculations of these minute Vessels, their heterogeneous Contents are continually and promiscuously running together.

7. THAT whilst they are circulating within these minute inosculating Vessels, they have an Opportunity given them, by the Make of the Lungs, and the large Expanse of Air to which they are exposed, not only of parting with some of the watery and serous Particles, with which they are loaded, but of receiving a Supply likewise of active and strongly-attractive Particles from the Air.

8. THAT all the Portions of the Blood and *Chyle*, which entered the Lungs of such different Constitutions, being there separated into the minutest Streams, and continually intermixed with each other; being eased of the Load of their watery and inactive Parts; and receiving in their stead a Supply of more attractive Particles of the Air: are, after a very short Passage, hurried all together thro' four small Veins in Comparison to the *Venæ Cavæ*, into the left *Sinus*, which conveys them to the Heart of the more lively Colour and uniform Consistence, which is peculiar to Arterial Blood, and which they wanted before.

AND, lastly, that after they have passed the Heart, they are circulated thro' Vessels which are strong, elastick, in continual Action, and grow narrower and narrower; by which Means the due Heat and proper Mixture is kept up and improved in the Blood, till it arrives again at the small Vessels of the Body, for whose Nourishment it is purposely designed.

IT is further to be observed, that the System of Pulmonary Veins, which receive the Blood and *Chyle* thus altered, and newly blended together, is less capacious, stronger, and more compact,

compact, in comparison to the corresponding System of Pulmonary Arteries, than any other System of Veins in the Body is, in comparison to theirs; and consequently, tho' they resemble the other Veins in growing wider and wider, yet by their being so strong and compact, as well as by their being so much shorter, than the other large Veins of the Body; the Blood thus newly mixed will not have the same Time or Opportunity allowed it to separate again, and return to its former depraved and broken Constitution, in its Passage thro' these to the Heart, that it had in the others.

THE Blood therefore begins to return to its Arterial Constitution in the small Vessels of the Lungs; and this beneficial Change is kept up, and improved, by the Action of the whole Set of Arteries in the Body.

THUS do we see how curious and constant a Provision is made by Nature to recruit the returning Blood with a fresh Supply of those nutritious and active Particles it must necessarily part with in every Circulation, and to restore that uniform Constitution it is so liable to lose during its Return thro' the Veins.

WE see likewise, that this advantageous Alteration made in the Blood, is not owing to any thing in the Make, Action, or Motion of the minute Blood-Vessels in the Lungs, different from those in other Parts of the Body; but proceeds,

1. FROM the Situation of these Blood-Vessels, with regard to the Heart, so as to be always receiving the reflux Blood, together with what *Chyle* is ready prepared, digested, and squeezed into it.

2. FROM the Situation, Make, Distribution, and Motion of the Air-Vessels of the Lungs; by which a constant Supply of fresh Air is continually admitted into the very inmost Recesses of the Vesicular Cavities.

3. FROM the peculiar Make of these Vesicles, the Distribution of the minute Blood-Vessels upon their Coats, and the Inos-

Inosculation among these Blood-Vessels; by which a Communication is made between the Air, the Blood, and *Chyle*, within the Lungs.

AND, lastly, from the different Nature of these Fluids thus brought together, and the Consequences of their mutual Actions upon each other, both whilst they are within the Lungs, and whilst they are circulating thro' the Body by the Force of the Heart and Arteries.

ALTHO' the most material Alterations which are made in the Blood may, perhaps, depend upon the mutual Action of component Particles of the Air, Blood, and *Chyle*, upon each other; and we may therefore very reasonably despair of ever being able to form an accurate Idea what these Alterations are, or how they are made, any farther than what has already been observed in general: yet, as we are certain from Experiment; that there is a constant, and very considerable, Discharge made from the Lungs; as we have Reason likewise to believe, that a considerable Quantity of the elastick Particles of the Air is admitted and taken into the Blood itself; and as we find so absolute a Necessity of a constant Supply of fresh Air, that we can live but a very few Minutes without it; it will certainly be worth our while to enquire, with greater Accuracy than we hitherto have done, into the Method in which the deep and inmost Recesses of the Lungs are alternately eased of that Air, which is loaded with Vapours, and supplied with fresh in its stead.

FOR, altho' the Lungs are alternately dilated and contracted, and consequently some Air is alternately admitted into them, and thrown out again; yet as they are never so compressed as to have all the Air contained within them entirely thrown out, and an equal Quantity of fresh Air admitted in its Place: the Air which lies deepest within the Lungs, *viz.* that in the Cavities of the Vesicles will not be thrown out at all by their alternate

ternate Motion; for upon the Contraction of the Lungs, it will be only pushed up higher into the larger Branches of the Bronchia, and upon their Dilatation it will fall down again into the same Cavities, and consequently from this alternate Motion of the Lungs alone, we can account for no more than a constant Supply of Air somewhere within the larger Air-Vessels: but for the continual Change of Air in the Vesicular Cavities, which is the only Place where it is of immediate Service, we must have recourse to some other Cause.

THIS other Cause is the elastick Quality of the Air, by which it is always observed to expand itself, and consequently become lighter, as it acquires different Degrees of Heat; and to condense and grow heavier, as it loses them again. The Consequence of which is, that almost as soon as any Air is admitted into the Lungs, it acquires a certain Degree of Heat above what it had before; by which it expands, and becomes lighter than common Air, and must, for that Reason, ascend and go out of the Lungs, and give room for the fresh and heavier Air to subside into its Place: and as the Vesicles lie the deepest within the Lungs; as the Air within them is almost in immediate Contact with the Blood; and as there is continually oozing thro' their Coats a watery Vapour, warm as the Blood it is immediately taken from: it will plainly follow, that the Air within these Cavities is the warmest and most dilated of any Air within the Lungs; and consequently will be continually ascending thro' the cooler and fresher Air, whilst that descends into its place: So that by this Circulation among the different Portions of Air within the Lungs, a fresh Supply of it is admitted into the Vesicular Cavities, and the watery and recrementitious Vapour discharged from the Blood, are conveyed away with the warmer Air which is expired.

IF with this View we again take the Fabrick of the Air-Vessels of the Lungs into Consideration, and compare the Make
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and Situation of the Air-Pipe and Bronchia, with the Make and Situation of the very minute Vesicles, we shall find the first of these particularly contrived to promote an easy Circulation among these different Portions of Air.

THE Wind-Pipe, the Bronchia, and the larger Branches of them, are plainly of a very strong cartilaginous Make, which resists the Pressure of the Parts about them; so that they are always (in Expiration as well as Inspiration) nearly of the same Capacity; and this sort of Make is continued, in a great Measure, thro' all, even the very minute Branches of the Bronchia. On the contrary, the Vesicles are of so fine a Contexture, that they yield to every the smallest Pressure, and are so situated towards the external Parts of the Lungs, that they are more immediately pressed upon by the Air in the Cavity of the Breast, than even the small Branches of the Bronchia are; and consequently must have their Cavities very considerably diminished during every Expiration.

So that we may in general affirm, that the Capacity of all the Vesicular Cavities taken together, will be very considerably diminished in every Expiration, in proportion to its Magnitude; and the Capacity of all the larger Air Vessels will not, in proportion to its Magnitude.

FROM this, therefore, it should seem, that the Vesicular Part of the Lungs, and the very minute Branches of the Bronchia, are more particularly affected by the alternate Motions of the Ribs and Diaphragm; and the Wind-Pipe and Bronchia (with regard to Respiration) are of no other Service, than to receive both the fresh and the old Air, and afford them convenient room to change Places according to their particular Gravities.

FOR the warm Air, when it is, by the Contraction of the Breast, squeezed out of the Vesicular Cavities into the Bronchia, has there Liberty given it to circulate; and by that time the Breast has dilated again, it has ascended thro' the fresher Air;

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which

which fresher Air, being descended into its Place, stands ready to supply the dilating Vesicles.

THUS may we account, with a tolerable Degree of Probability, as well as Accuracy, for the Manner in which both the Discharge made from the Blood in the Lungs is carried off with the warm Air, and the Supply of fresh Air is taken into the Vesicles in its Place; and if we consider, that this is continually doing, without any the least Interruption when we are in perfect Health, we may easily conceive how so great a Discharge may be made, tho' in the Form of a Fluid too subtle to be the Object of our Sight.

I HAVE dwelt the longer on this Subject, and been more particular in explaining this Nicety in the Manner of our Breathing, because it will greatly assist us in forming a Judgment of what seems at present the most probable way of accounting for the absolute Necessity we are under of having a constant Supply of fresh Air.

IN order to settle this Point, several have tried Experiments, both on themselves, as long as they could bear them; and on Animals, till they expired. They themselves found the greatest Uneasiness in breathing the same Air after two or three Minutes; and the Animals all of them died, tho' some lived much longer than others.

THE same sort of Experiments were tried with burning Candles, lighted Brimstone, &c. confined to the same Air, in a large Receiver; and Flame, as well as Life, was found to subsist no longer than fresh Air was admitted to its Support.

HENCE those, who first made these Experiments, imagined that there were certain Particles, friendly to Life and Flame, equally distributed in every Portion of Air; and that when these were exhausted, either by the Breathing of an Animal, or the Flame of any burning Substance, That Portion of Air became entirely useless; and unless another fresh one, with its Recruit
of

of friendly Particles, was admitted, the Animal died, and the Flame went out. These were afterwards supposed to be nitrous Particles; and accordingly That Air was esteemed the most healthy which abounded most with Nitre.

BUT when Dr. *Hales*, in his *Analysis of the Air*, repeated these Experiments, with some little Difference in the Manner of making them, he soon found good Reason to suspect the Insufficiency of this way of accounting, either for the Death of the Animals, or the going out of the Flame.

HE added to these, several new Experiments of his own; and from the Whole, he was rather inclined to believe They were owing to the Loss of Elasticity in the component Particles of the Air itself; which he found, by his Experiments, always followed upon admitting either the Smoak of burning Candles, Brimstone, &c. or the Vapours exhaled along with the Breath of living Animals, into the Air confined in a Receiver. *Vide* the Experiments, and the Reasoning upon them, from *Exp. 102.* to the End of the *Analysis of the Air*, in the *Vegetable Statics*.

As there is some Nicety in this way of accounting for the Death of Animals, which are long confined to breath the same Air; and consequently, for the great Uneasiness any Person feels upon attempting to do the same for more than a Minute or two; and as what the Doctor has said upon this Subject is dispersed about in several Parts of his Two Volumes; I hope I shall be excused, if I collect all that can be said upon it, and set it in one View; in order that it may be the more readily embraced, if it be true, or more easily confuted, if it be false.

HE tells us in his *Appendix* to the *Hæmaphys*. p. 323, that he made Use of the following Method to try, with the greatest Ease and Accuracy, how long he could breath, to and fro, the same Air, and to find how much of its Elasticity was in that Time destroyed.

“ I CEMENTED (says he) fast at a Hole in the Top of an
 “ Air-Pump Receiver, a Wooden Foffet. I set this Receiver
 “ in a wide Vessel, which had two Inches depth of Water in it,
 “ leaving room at the Bottom for the Water to pass freely to
 “ and fro. In this Position, the Quantity of Air in the Re-
 “ ceiver was equal to 522 Cubick Inches. Then, stopping my
 “ Nostrils, I first breathed out what Air I could from my
 “ Lungs, and then applied my Mouth to the End of the Fof-
 “ fet, where I breathed to and fro the 522 Cubick Inches of
 “ Air for two Minutes and a half; when growing uneasy, I
 “ breathed all the Air I could from my Lungs, as at the first;
 “ and at the same time giving a Signal to a Stander-by to mark
 “ the Height of the Water in the Receiver with a Piece of
 “ Chalk, I found upon measuring, that 18 Cubick Inches, or
 “ $\frac{1}{29}$ th Part of the whole Air, was in that Time reduced from
 “ an elastick to a fixed State: But some further Allowance is
 “ to be made on Account of the Expansion of the Air in the
 “ Receiver, by reason of the Heat it had received in Respira-
 “ tion.”

UPON this Experiment we may make the following Obser-
 vations.

1. WHILST the Air, included within the Receiver, was
 freely taken in, and thrown out of the Lungs, there was conti-
 nually admitted into it what Vapours were exhaled from the
 Vesicular Cavities of the Lungs, and thro’ the Coats of all the
 Parts between the Lips and those Vesicles.

2. NONE of the Particles of included Air and Vapour have
 any Means to escape thro’ the Glass or Water; nor is it to be
 supposed, that in so short a time as two or three Minutes, any
 considerable Quantity of them could be absorbed and taken in-
 to the Blood; and,

3. CONSEQUENTLY, the Receiver, Mouth, Throat, and
 Lungs do, at the End of that Time, contain all the Particles of
 Air

Air which they contained at first, together with the Vapours exhaled into them.

4. SINCE the Water rises in the Receiver, by the Pressure of the external Air upon the Surface of the Water in the large Vessel, these Particles must lie closer together than they did before, without pressing more upon the Water than when they had the whole Receiver to possess.

5. CONSEQUENTLY, either every Particle of Air must have lost Part of its Elasticity, or Part of them have lost it all, and have entirely changed from an elastick repelling Condition to a strongly attracting one.

6. SINCE the Water (in other Experiments tried in the same manner) is found to rise after the Receiver, and Air, and every thing is cool, and left to itself; it seems reasonable to conclude, that the Vapours exhaling from the Lungs do so strongly attract the Particles of the Air, in which they swim, as to incorporate with them, and prevent their flying off, and becoming elastick again.

7. FROM what was said above, Respiration is best carried on when the Air we breath is perfectly elastick, and when That Portion of it, which is to be taken into the Lungs, is of a proper Degree of Coolness, in comparison to the Warmth of the Vapours exhaled from the Blood into the Vesicular Cavities; because the free Circulation of the Air in the Lungs depends entirely upon these Properties of the Air.

8. IN this Experiment, therefore, the oftener the Portion of Air, contained in the Receiver, has been breathed to and fro, and passed thro' the Vesicular Cavities of the Lungs, it will not only be more and more loaded with Vapours, which we find by Experience destroy its Elasticity, but it will likewise come nearer and nearer to the same Degree of Warmth with the Air in those Cavities; and consequently, will lose more and more of those Properties, Coolness and Elasticity, upon which the Circulation

culuation of the Air within the Lungs depends, and by which the Air is perpetually changing in ordinary Respiration.

9. IT is evident, therefore, from this way of Reasoning, that there must be a Time after which the Air in the Vesicular Cavities can no longer be changed for the Air in the Receiver.

10. THIS Time appears, from this Experiment, to be about three Minutes in human Lungs: for it is reasonable to suppose, that the Uneasiness in breathing arises wholly from the Want of this Change of Air in the Lungs; which I am now to shew.

Dr. Hales expresses himself thus, in *Exp. III. Veget. Stat.*
 “ It is plain, from the Effects of the Fumes of burning Brim-
 “ stone, lighted Candles, and the *Breath of Animals*, on the
 “ Elasticity of the Air, that its Elasticity in the Vesicles of the
 “ Lungs must be continually decreasing, by reason of the Va-
 “ pours it is there loaded with; so that those Vesicles would,
 “ in a little time, subside, and fall flat, if they were not fre-
 “ quently replenished with fresh elastick Air at every Inspira-
 “ tion, thro’ which the inferior heated Vapour and Air ascends,
 “ and leaves room for the fresh Air to descend into the Vesi-
 “ cles.”

“ BUT when, instead of these frequent Recruits of fresh
 “ Air, there is inspired an Air furcharged with acid Fumes and
 “ Vapours, which not only, by their Acidity, contract the exqui-
 “ sitely sensible Vesicles, but also, by their Grossness, much re-
 “ tard the free Ingress of the Air into the Vesicles; many of
 “ which are exceeding small, so as not to be visible without a
 “ Microscope; which Fumes are likewise continually rebating
 “ the Elasticity of that Air: then the Air in the Vesicles will
 “ lose its Elasticity very fast, (*Vide Exp. 107, 108.*) and, con-
 “ sequently, the Vesicles will fall flat, notwithstanding the En-
 “ deavours of the extending Thorax to dilate them as usual;
 “ whereby the Motion of the Blood thro’ the Lungs being
 “ stopped, instant Death ensues.”

“ WHICH

“ WHICH sudden and fatal Effect of these noxious Vapours
 “ has hitherto been supposed to be wholly owing to the Loss
 “ and Waste of the *Vivifying Spirit of Air*, but may not
 “ unreasonably be also attributed to the Loss of a considera-
 “ ble Part of the Air’s Elasticity, and the Grossness and Den-
 “ sity of the Vapours which the Air is charged with ; for mu-
 “ tually attracting Particles, when floating in so thin a Me-
 “ dium as the Air, will readily coalesce into grosser Combina-
 “ tions: which Effect of these Vapours, having not been duly
 “ observed before, it was concluded, that they did not affect
 “ the Air’s Elasticity; and that, consequently, the Lungs must
 “ needs be as much dilated in Inspiration by this, as by a clear
 “ Air.

“ BUT that the Lungs will not rise and dilate as usual, when
 “ they draw in such noxious Air, which decreases fast in its
 “ Elasticity, I was assured, by the Experiment I made on my
 “ self, in *Exp.* 107 ; for when, towards the latter End of the
 “ Minute, the suffocating Quality of the Air in the Bladder
 “ was greatest, it was with much Difficulty that I could dilate
 “ my Lungs a very little.”

IN our present Experiment, the Air in the Receiver is loaded
 with no other noxious Vapours than what are exhaled from the
 Lungs in Respiration ; but after this Air is become so warm,
 and has lost so much of its Elasticity, that it can no longer cir-
 culate, and by that Means pass into the Vesicular Cavities, the
 Air, which remains there unchanged for fresher Air, must be
 continually loaded with more and more of these Vapours; which
 we know will destroy the Elasticity the faster, the greater the
 Proportion is which they bear to the Air which sustains them.

AND if it be true, as Dr. *Hales* suspects, that mutually at-
 tracting Particles, floating in so thin a Medium as Air, will
 very readily coalesce into grosser, and still grosser Combinations :
 is it unreasonable to suppose, that at last these Combinations
 will

will be too gross to pass from the Branches of the Bronchia, into which they are squeezed in Expiration, back again into the exceedingly minute Vesicles?

AND will not the Air, remaining still behind, within the Vesicles continue losing more and more of its Elasticity?

AND when no more Air can enter to dilate the Vesicles, will not the Weight of the external Air, upon the Abdomen, force the Diaphragm up into the Cavity of the Thorax? Will not this compress the Air in that Cavity? And the Air in the Cavity, of course, compress the Vesicular Parts of the Lungs, which it immediately surrounds; till at last all the Vesicles become so flattened and squeezed together, as to prevent the Blood from circulating thro' the Vessels distributed upon their Coats?

Is not the Consequence of this last State, certain and immediate Death? And when, in this Experiment, the Air had been breathed between two or three Minutes, and the Air within the Lungs was continually approaching nearer and nearer to the State described above, Was not the great Uneasiness felt in continuing to breath this Air, the Consequence of the Vesicles beginning to collapse, and the Blood's beginning to circulate with Difficulty? At least, Is not this the most reasonable Way of accounting for this Uneasiness?

IT HAS BEEN OBJECTED, I know, that the Water which rises into the Receiver (by compressing the Air contained within it and the Lungs) keeps it always of the same Degree of Elasticity with the external Air; and consequently, that the Lungs are as much pressed within by this Air, as they would be by the fresh external Air; and consequently, that they may as easily be dilated by one as the other.

To this it may be answered, that perhaps the inner Surface of the Wind-pipe and Bronchia may be pressed as much by this Air, as the external Surface of the Lungs is by the Air in the Cavity; but if the Air in the Bronchia, loaded so with Va-

pours

pours, cannot enter the Vesicular Cavities, then the *internal Surfaces of the Vesicles* are not equally pressed with their *external*; and consequently, as the Pressure within is continually decreasing, whilst that without continues the same, the external Pressure will soon occasion great Uneasiness, and soon after Death itself.

IT HAS BEEN OBJECTED too, that Air less elastick and more loaded with Vapours, than that in the Receiver, even at the End of the Experiment, is often breathed without occasioning such Uneasiness, as the Doctor felt in making this Experiment.

To this it may be answered, that the Air in the Receiver is no otherwise the Occasion of the Uneasiness in breathing, than as it prevents that Circulation upon which the Change of Air in the Vesicles depends; and perhaps Air less elastick and more loaded with Vapours, if those Vapours were cooler, might not do so.

THE Air in the Receiver is loaded with Vapours of the same sort, and has lost Part of its Elasticity in the same manner with the Air in the Vesicles, and the small Branches of the Bronchia, but not in the same Degree; and, perhaps, if the Vesicles could be constantly supplied with no fresher Air, than that in the Receiver, so as not to have it continue long enough in them to grow worse and denser, and more loaded with gross Combinations, Respiration might go on without any very great Uneasiness. But this the Circumstances of the Experiment will not admit of.

IT seems reasonable to believe this, from the 114th Experiment of Dr. Hales, *Veget. Stat.*

“ I TYED, says the Doctor, a middle-sized Dog alive on the
 “ Table, and having laid bare his Wind-pipe, I cut it asunder
 “ just below the *Larynx*, and fixed fast to it the small End of
 “ a common Foffet, the other End of the Foffet had a large
 “ Bladder tyed to it, which contained 162 Cubick Inches; and
 “ to the other End of the Bladder was tyed the great End of

“ another Foffet, whose Orifice was covered with a Valve,
 “ which opened inward, fo as to admit any Air that was blown
 “ into the Bladder, but none could return that Way ; yet, for
 “ further Security, that Passage was alfo flopped with a Spig-
 “ got.”

“ As foon as the firft Foffet was tyed faft to the Wind-pipe,
 “ the Bladder was blown full of Air thro’ the other Foffet.
 “ When the Dog had breathed the Air in the Bladder to and
 “ fro for a Minute or two, he then breathed very faft, and
 “ fhewed great Uneafinefs, as being almoft fuffocated.”

“ THEN with my Hand I preffed the Bladder hard, fo as
 “ to drive the Air into his Lungs with fome Force, and there-
 “ by make his *Abdomen* rife by the Prefsure of the *Diaphragm*,
 “ as in natural Breathings ; then taking alternately my Hand
 “ off the Bladder, the Lungs with the *Abdomen* fubfided.”

“ I CONTINUED in this manner to make the Dog breathe for
 “ an Hour ; during which time I was obliged to blow frefh
 “ Air into the Bladder every five Minutes, three Parts in four
 “ of that Air being either abforbed by the Vapours of the
 “ Lungs, or efcaping thro’ the Ligatures, upon my preffing
 “ hard on the Bladder.”

“ DURING this Hour, the Dog was frequently *near ex-*
 “ *piring* whenever I preffed the Air *but weakly* into his Lungs,
 “ as I found by his Pulse, which was very plain to be felt in
 “ the great *Crural* Artery near the Groin ; but the languid
 “ Pulse was *quickly* accelerated fo as to beat *faft* foon after I
 “ dilated the Lungs *much by preffing hard* upon the Bladder,
 “ efpecially when the *Motion of the Lungs was promoted* by
 “ preffing alternately the *Abdomen* and the Bladder, whereby
 “ both the Contraction and Dilatation of the Lungs was encrea-
 “ fed.”

“ AND I could, by *this Means*, rouse the languid Pulse
 “ *whenever I pleased*, not only at the End of every five Mi-
 “ nutes,

“ nutes, when more Air was blown into the Bladder from a
 “ Man’s Lungs, but also *towards the End of the five Mi-*
 “ *nutes, when the Air was fullest of Fumes.*”

“ At the End of the Hour, I intended to try, whether I
 “ could, by the same Means, have kept the Dog alive some
 “ time longer, when the Bladder was filled with the Fumes of
 “ burning Brimstone : But being obliged to *cease for a little*
 “ *time from pressing the Air into his Lungs*, while Matters
 “ were preparing for this additional Experiment, in the mean
 “ time the Dog died, which might otherwise *have lived longer,*
 “ *if I had continued to force the Air into his Lungs.*”

“ Now, tho’ this Experiment was so frequently disturbed,
 “ by being obliged to blow more Air into the Bladder twelve
 “ times during the Hour ; yet since he was almost suffocated in
 “ less than two Minutes by breathing of *himself* to and fro the
 “ first Air in the Bladder, he would (by Experiment 106, on
 “ Candles) have *died in less than two Minutes*, when one
 “ fourth of the old Air remained in the Bladder, immediately
 “ to taint the new admitted Air from a Man’s Lungs ; so that
 “ his continuing to live thro’ the whole Hour, must be owing
 “ *to the forceable Dilatation of the Lungs by compressing the*
 “ *Bladder*, and *not* to the *Vivifying* Spirit of the Air ; for
 “ without that forceable Dilatation, he had, after the first five
 “ or ten Minutes, been certainly dead in less than a Minute,
 “ when his Pulse was so very low and weak ; which I did not
 “ find to be revived barely by blowing three Parts in four of
 “ the new Air from the Lungs of a Man into the Bladder :
 “ But it was constantly roused and quickened, whenever *I en-*
 “ *creased the Dilatations of the Lungs by compressing the*
 “ *Bladder more vigorously* ; and that whether it was at the
 “ Beginning, or End of each five Minutes : yet it was more
 “ easily quickened, when the Bladder was at any time newly
 “ filled, than when it was empty.”

HENCE it appears, that altho' the Air in the Bladder was so much loaded with Vapours, that the Animal must have expired in a Minute after the first five or ten Minutes, if it had been left to itself ; yet the meer squeezing this Air forceably into its Lungs, did immediately revive its languid Pulse, and the constant Repetition of it preserved it from expiring for an Hour, which even the Admission of the fresh Air, every five Minutes, could not have done. Now, the only Effect of squeezing the Air thus forceably into the Lungs, that we know of, is dilating their Vesicles, and giving room for the Blood to circulate freely thro' them ; and consequently, we may safely conclude, that the languid Pulse, and the approaching Death of the Animal, was owing entirely to the Vesicles collapsing very fast, for want of elastick Air within them to keep them sufficiently dilated.

AND by Parity of Reasoning, the great Uneasiness which the Doctor felt at the End of his Experiment, was owing entirely to the Want of Change in the Air within the Vesicular Cavities of his Lungs ; which we have shewn must be the Consequence of his Experiment.

THERE remains only one Point to be settled, before we conclude this Lecture, and that is in what manner the Particles of Air are taken into the Blood : and after what has been said, we shall find no great Difficulty in it.

FOR if we consider, that at the Surface of the Body there are not only Pores, thro' which the perspirable Matter passes out, but others also, which are ready to imbibe the Moisture which is near them ; and that in all the Cavities of the Body there must be absorbing Vessels to take up the Vapours, which are continually exhaled into them, in order to prevent their increasing to such a Degree as to occasion a Disease ; we may reasonably conclude, that there are similar absorbing Vessels in the Vesicles of the Lungs.

CONSEQUENTLY in a healthy State of the Lungs, whilst a perfect Respiration is kept up; and whilst there is continually oozing thro' the Coats of the Vesicles a Vapour, which we know from Experiments attracts the Particles of Air, incorporates with them, destroys their elastick Quality, and keeps them in a strongly attracting State; Part of this Vapour must be sucked in by these absorbing Vessels, and carried into the Blood, and circulated all over the Body; and together with it, the Particles of Air thus absorbed, and taken into it: which could not, in their elastick State, have found Admittance.

I SHALL now conclude with the following Queries, which I submit to a further and more mature Consideration.

DOES not the Blood contain the Particles, which are designed by Nature for the Nourishment of the Body, and which are to be conveyed by the Circulation to every Part of it?

DOES not the Blood in the Arteries abound most with these nutritious Particles? And, are not the different Fluids which compose it, so well blended and mixed together, that it is every where alike, and of a due Consistency to pass thro' the minutest Vessels of the Body?

DOES not the Blood begin to lose this its Arterial Constitution in these minute Vessels of the Body, and grow more and more depraved, the further it advances towards the Heart in the large Veins? and when it arrives at the Heart, is it not the most broken and disunited that it is capable of being in that particular Circulation?

Is not this its broken Constitution at the Heart owing, first, in general, to its most attractive Particles having escaped in Perspiration and Secretion, or having been left behind in Nutrition; and to the remaining Fluid's having been for a considerable Time, and in a great Degree, left to itself in large inactive Vessels, with little or no Motion; by which the different Fluids
which

which compose it have had Liberty given them to separate into distinct and improper Combinations? And, secondly, in particular, to the Heart's being so situated as to receive at one and at the same time the reflux Blood, both from the superior Parts of the Body, just after the Chyle is squeezed into it, and from the inferior Parts, just after it has received the Blood from the Liver, without either of these being duly mixed and blended with it; which Blood coming immediately from the Liver, may reasonably be supposed to be the most broken of any of the reflux Blood, because it has not only gone thro' the Office of Nutrition in its Arterial State, but even in its Venal State has had the Bile secreted from it, and consequently has parted with that Fluid which mixes the best with the other Fluids in the Blood, and unites and keeps them blended together in one uniform Mass?

MUST not this broken and disunited Blood, if it was to continue without any Recruits of attractive and nutritious Particles, or without having its component Fluids more intimately blended and mixed together, return to the Heart, after every Circulation, more and more depraved and disunited; and at last become utterly unfit for the Purposes of Life?

DOES not the reflux Blood, therefore, immediately before the Heart transmits it to the Lungs, receive a Supply of Chyle, prepared by Nature for the Nourishment of the Body, tho' it is loaded with a considerable Quantity of watery and recrementitious Particles?

AND whilst this Chyle and reflux Blood are circulating thro' the Lungs, Are not the different Fluids, which compose them, continually and promiscuously mixed and blended together, by the numberless Inosculation amongst their minutest Blood Vessels?

AND whilst they are thus mixing together, Is there not continually oozing into the Vesicular Cavities, a Vapour composed

posed of their most watery, serous, and recrementitious Particles?

Is not this Vapour of such a Nature, as to absorb and take into it the elastick Particles of the Air, admitted into those Vesicular Cavities?

Do not these Particles of Air, thus absorbed, lose their Elasticity, become strongly attractive, and adhere closely to the component Particles of this Vapour?

Is not one Part of the Vapour, with the Particles of Air taken into it, supported in, and carried off, by the warmer Air we breath out at the Mouth and Nostrils?

AND is not the other Part of it, with its share of Air Particles, taken into the Blood again by the absorbent Vessels in the Coats of the Vesicles?

IF we once allow, that the Particles of Air are taken into the Mass of Blood, must we not at the same time suppose them to be as ready to resume their elastick State, and as active in producing Warmth and Heat, whenever the Blood is briskly agitated in the Vessels of the Body, as they are known to be in other Substances, in which they lie absorbed; and for the same Reason, whilst they are undisturbed, to be as serviceable in increasing the Cohæsion of the Parts they are near, whether solid or fluid?

ARE not the red Globules, which swim in the thinner Fluid of healthy Blood, known to retain their Globular Form only from their Parts cohæring more strongly to one another, than to the serous Part of the Blood? And, may they not therefore be looked upon as the most attractive and powerful Part of the Blood?

AND since Water is the least susceptible of Heat, from Friction, of any Fluid which enters the Composition of Blood, can it be the serous? Is it not rather the Globular red Part of the Blood, which first acquires and chiefly produces Heat by the Force of the Circulation?

FROM

FROM this, compared with what was said before, is it too chimerical to suppose, that the Particles of Air, thus absorbed, and taken into the Blood, do, in their Progress thro' the Lungs and the larger Arteries of the Body, mix with the Mass of Blood and Chyle; and joining themselves to the most attractive Part of them, form together, by their mutual Attraction, the Globular red Part of the Blood, which, by the Force of the Circulation, and the Friction of the Parts, keeps up that natural Warmth which is so necessary to the well-being of the whole Body?

AND as the Velocity of the Blood is found to be greater in the Lungs, than in any other Part of the Body, would not this Heat be more remarkably felt in this Part, if the constant Accession of cool Air did not continually temper, and keep it pretty nearly at a Par with that of the other Parts?

ARE not the Lungs, therefore, contrived, and situated as they are, that the reflux Blood may, as it passes thro' them, be gradually recruited with the active and nutritious Particles it is continually losing in the Offices of the Circulation, and at the same time relieved from the improper Combinations its component Fluids may have fallen into in its return thro' the Veins, by a constant Discharge of the most watery and serous Parts of them in the Air we breath, and by the remaining Fluids being duly and intimately mixed with the fresh Supplies of Chyle and Air?

Is not the Use of Respiration, in the Animal Oeconomy, to promote the Discharge of the recrementitious Particles, and to supply the Blood with more active and beneficial ones in their stead?

Is not the Air we breath the Means of conveying away the Vapour exhaled from the Lungs? And, is not that Vapour, in its turn, the Means of conveying the Supply of Air into the Blood? And, could either of these be effected without their mutual Action upon each other?

ARE

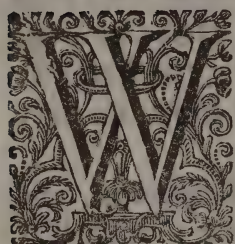
ARE not the Vesicular Cavities of the Lungs the Seat where these necessary Works are continually carried on, as the Condition of the Body requires? And, are they not most conveniently situated for this Purpose, out of the immediate Influence of the common Inclemencies of the Weather? And, lastly, are not the regular Returns of Expiration and Inspiration perpetually kept up, in order to remove the warmer Air, loaded with Vapours, into the larger Branches of the Bronchia, where it has room to circulate thro' the cooler and heavier Air taken in at the Wind-pipe; and to receive this fresher Air in its stead: by which the Air in those Cavities is never allowed to lose too much of its Elasticity, and the Vapours exhaled from the Lungs are prevented from forming themselves into too gross Combinations, and so overcharging, and at last stopping up, the Entrance into the Vesicular Cavities; the Consequence of which we have seen would very soon be fatal?

THIS is all I have to offer on the Use of Respiration, and the Office of the Lungs, in the Animal Oeconomy: And, if I have any where given too much Way to Conjecture, I hope it will be imputed to the Nicety of the Subject, and minute Structure of the Parts, which will not admit of that Variety of Experiments, which may be necessary to a thorough Conviction.

LECTURE III.

OF THE

Diseases of the ORGANS *of* RESPIRATION.



WHEN we are in Health, and Respiration is carried on in the best and most perfect Manner, the Chest is alternately raised, and depressed; the Abdomen swells, and subsides; and the Air is breathed in and out through the Mouth and Nostrils with Ease, Constancy, and a sort of Pleasure: and these Motions are performed with the same Freedom in moderate Exercise, as when we are at Rest.

Now as these Motions have been shewn to be the natural Consequences of the Make of the Chest and Abdomen, and of the alternate Actions of the Muscles described above, as well as of the Make and Situation of the Lungs themselves, and the Nature of the Air we breath; it will follow, that the regular, constant, and easy Performance of them is an Indication of the Health and proper Action of all the Parts concerned in Respiration.

FOR the same Reason, when either there is some wrong Formation of any of these Parts, or they have received any accidental Injury; when their Actions are any ways disturbed, or when the Air itself is not of a due Coolness or Elasticity; the Ease, Constancy, and Regularity, of these outward Appearances in Respiration will be proportionably disturbed, and differently affected,

affected, as this or that Part is prevented from performing its Share in the Action of Respiration; and these external Appearances so disturbed, are the Symptoms attending upon the Diseases of the Organs of Respiration, and the necessary Consequences of the imperfect Actions of these Organs so diseased.

WE shall in this Lecture, therefore, take a Review of all the different Parts described above, and consider them in a different Light from what we did before, in order to point out what particular Changes in the outward Appearances will follow upon any Disease in one or more of them.

SUCH a Review will not only be of Service to us in deducing the Seat of any Disease from the Symptoms which attend upon it, and consequently in directing us to the Method we ought most reasonably to follow in our Attempts to remove it; but it will likewise assist us in our Philosophical Enquiries into this Part of the Animal Oeconomy.

FOR since the Symptoms which attend any Disease are the true and necessary Consequences of the imperfect Actions of the Parts, whilst they are disordered; they may be derived from the particular Disorders to which they are owing, provided we are sufficiently acquainted with the true Make of the Parts, and all the Requisites to their acting properly: and consequently, so far as we are able, from the Seat and first Cause of a Disease to derive the Symptoms which attend it, so far, and no farther, may we depend upon the Goodness of our Theory of the Animal Oeconomy.

EVERY Disease, therefore, with its Train of Symptoms, considered in this Light, is a sort of Experiment offered us by Nature herself, by which we may fairly try how far our Knowledge extends, and whether the Notions we have entertained in our Attempts to explain the Animal Oeconomy are well or ill grounded, and consequently whether they are to be retained or rejected.

LET us now begin this Review ; and whilst the particular Disorders of any one or more of the Parts concerned are under Consideration, let us suppose the others perfectly in Health, and properly constructed.

FIRST, we have seen the Necessity there is for the alternate dilating and contracting of the Cavity of the Breast ; and that it is performed, partly by the Action of the Intercostal Muscles, which alternately raise and depress the Ribs, and partly by the Action of the Diaphragm and Abdominal Muscles, which alternately force the Contents of the Abdomen into and out of that Cavity.

WHEN we are in Health, and Respiration is carried on without our attending to it, both these Sets of Muscles perform their proper Shares in enlarging and contracting the Cavity of the Breast : But however, we can, if we please, hold the Ribs fixed, and sufficiently enlarge and contract it, by the Actions of the Abdominal Muscles and Diaphragm only ; and in the same manner, tho' not in so great a Degree, we can lay the Labour upon the Intercostal Muscles.

WHAT we can thus perform at our Pleasure, when in Health, we experience to be of Service, when either of these Sets of Muscles are diseased and in pain ; tho' it is then performed by a sort of Instinct, and without our Will or Attention.

THUS it frequently happens, that they, who are subject to Rheumatisms, have their Pains determined to the Intercostal Muscles, and fixed there, so as to give acute Pain, and occasion a great Difficulty, in Breathing. In this Case, the Action of Respiration is remarkably and laboriously carried on by the Diaphragm and Abdominal Muscles only.

IN the same Manner, when the free Motion of the Diaphragm into and out of the Cavity is prevented by a Disease either in itself, in any of the Contents of the Abdomen, or in the Abdominal Muscles ; Nature most carefully relieves those Parts
from

from a Motion, which must be attended with great Uneasiness by performing the whole Work of enlarging and contracting the Cavity by the Motion of the Ribs only ; for which purpose she calls to her Assistance almost all the Muscles, which are affixed to them, tho' many of them are principally design'd for other Uses.

Two Cases, of this kind, I saw myself in *St. George's Hospital*; which were so remarkable, that they seem worth relating.

THE First was that of a Workman who fell from the Timbers in the Roof of a House he was building, thro' the Jice of every Floor into the Cellar, and lighting upon his Buttocks, escaped without breaking or dislocating a single Bone. Together with all the Symptoms of being terribly bruised both within and without, he had a very remarkable Difficulty in Breathing, which was laboriously performed by the Motion of the Ribs only. He had frequent Returns of very violent Fits of Sneezing; and being asked by his Physician, whether he could fetch a deep Sigh, and ordered to try; he answered, No; he wished he could; he wanted to sigh; if he could but sigh, he was sure he should find Ease.

BESIDES Bleeding, which gave him little or no immediate Ease in Breathing, and proper Care taken of him in other Respects, his Abdomen was ordered to be swathed up tight. Soon after this was done, he fetched several deep Sighs, which gave him great Ease; and within less than four and twenty Hours, the great Difficulty of Breathing was removed, and he soon recovered.

IT seems in this Case, as if the Teguments of the Abdomen, together with the Abdominal Muscles, were by the Fall from so great a Height directly upon the Buttocks, stretched beyond their Tone by the Weight of their Contents, and had not Power afterwards to promote the Action of Respiration by squeezing their Contents up against the Diaphragm. But when the Weight
of

of their Contents was supported by the Swathing up of the Belly, they soon recovered their Action, and gave their usual Assistance in Sighing and Respiration.

THE other Case was that of a Girl about three Years of Age, who had a small Swelling on the Back, situated on the lower small Ribs on the Right Side, about the Bigness of a Walnut. The Swelling was soft, and plainly contained Matter, which, upon squeezing, receded into the Cavity; the Right Side of the Thorax was remarkably swelled and puffed up, insomuch, that notwithstanding the Child was every where else emaciated to the last degree, neither the Ribs themselves, nor any Motion of them in Respiration could be perceived on that Side; but on the Left Side, they were as visible as they are in all emaciated Subjects, and the whole Action of Respiration was performed by the Intercostal Muscles of this Side only, excepting some small Assistance they received from the Abdominal Muscles, which had squeezed the Contents of the Abdomen from the Right Side, where they must have pressed too much against the loaded Part of the Diaphragm, to the Left, so as to bunch out there in an unnatural Manner. Upon opening this Tumour there came out a very surprising Quantity of Matter, the discharge of which affected the Child's Breathing so much, and occasioned such an Alteration in the Manner of performing it, that the Surgeon was forced several Times to stop the Orifice with his Finger to give her Time to recover her Breath: And it was very curious to observe, as the Matter was thus gradually discharged, how the Right Side gradually resumed its share in the Action of Respiration, till after it was all out, both the Right and the Left Side very visibly contracted, and dilated together, nearly with equal Degrees of Motion.

THESE Instances are sufficient to shew us how industriously Nature provides for the Ease of any Parts that are disordered,
by

by encreasing the Action of those that are well; the Knowledge of which may be of great Service to us, as Physicians.

FOR the encreased Action of the Parts, which are not disordered, designed thus by Nature for the Relief of those that are, does at the same Time serve for a Direction to the Physician, and points out to him the particular Parts in which the Disorder is seated.

THUS when we see either the Breast, or the Abdomen, laboriously performing the Action of Respiration by it self, without the Assistance of the Other; we may conclude that the other is either disordered itself, or prevented from performing its Share of the Action by the Disorder of some other Part, which must necessarily be put in Motion by it.

AND when they both of them act equally laboriously, we may conclude that the Seat of the Disorder is in neither of them, but lies deep within, and most probably in the Lungs themselves.

IN THE NEXT PLACE, let us take a general View of the neighbouring Parts, which will upon any Disorder in them more particularly interfere with the Action of Respiration.

THE inner Surfaces of the Ribs, and Intercostal Muscles and Diaphragm, and the whole External Surfaces of the Lungs and Pericardium, are most exactly covered by the Pleura; which is a smooth strong Membrane stretched over, and lining the whole Cavity of the Breast, and forming by its Duplicatures the Mediastinum, which divides the Cavity into Two.

THIS Membrane, when it is in perfect Health, is pliable in every Part of it, that it may conform itself to the perpetual Motion of all the Parts it covers; but as it is furnished plentifully with Arteries, Veins, and Nerves, it must be liable, like other Parts of the Body, to Obstructions, Inflammations, Pain, and Suppuration; and, therefore, whenever it is in any Part of it afflicted with any of these Disorders, it must necessarily very remarkably

remarkably disturb the Actions of the Parts it is stretched over; and, according as the Part affected is applied to the Ribs or Diaphragm, the Latter or the Former will be obliged to perform the greater Share in the Action of Respiration.

THE Diaphragm is lined on the other Side with the Peritoneum, as exactly as on this with the Pleura, and immediately below it lie the Liver and Stomach.

ANY Obstruction, Inflammation, Pain, &c. in the Peritoneum, will as greatly interfere with the Action of the Diaphragm, as they would if they were seated on the other Side of it in the Pleura itself. The same Disorders in the Liver, or Stomach, or Spleen, or indeed in any other of the Contents of the Abdomen, will proportionably affect Respiration, as they give greater or less Uneasiness and Pain, when they are squeezed up and down by the Diaphragm and Abdominal Muscles in the Action of Respiration.

BUT as the external Coat of the Liver is continually applied to that Part of the Peritoneum which lines the lower Surface of the Diaphragm, there frequently happens an actual Adhæſion of one to the other, which is in reality a Disease; and tho' it makes little or no Alteration in Respiration when these Parts are both of them otherwise in Health, yet in an Inflammation of the Liver, which we have most Reason to believe has its Seat in this external Membrane, it greatly affects Respiration, and brings on such Pain, and so many of the same Symptoms which attend a Pleurisy, that an unskilful or unattentive Practitioner may very easily be deceived.

IT is easy to see likewise, that the Quantity of Water contained in the Abdomen in an Ascites must greatly interfere with the Action of Respiration; and the more so, the more the Quantity of it encreases. For whilst that Quantity is small, the only Inconvenience it is of to Respiration is owing to its Weight, and the Abdominal Muscles must therefore act with greater Force.

But

But when the quantity of Water is so great, as to distend the Teguments of the Abdomen to their greatest Extent, and brace them tight, the Diaphragm must of Consequence be as forcibly squeezed up into the Cavity of the Thorax, as the Teguments of the Abdomen are squeezed outwards; and neither of them will have the power of moving at all: Whence it will follow, that the Muscles, inserted into the Ribs, must perform the whole Action of Respiration by themselves.

THUS have we seen how the neighbouring Parts, when they are disordered, may interfere with, and disturb, the Action of the Muscles which enlarge and contract the Cavity of the Breast; and the Alterations in the External Appearances in Respiration, which are the Consequences of those Disorders.

AND in general we find that, when the Muscles, which raise and depress the Ribs, or those which swell and contract the Abdomen, are any ways separately disordered, or prevented from acting freely, Respiration is laboriously carried on by the other Set only.

THIRDLY, when the Lungs themselves do not dilate and contract with ease and freedom, the Muscles which raise and depress the Ribs, and those which swell and contract the Abdomen, must both of them act laboriously, and with more force than they naturally do.

IN order to see this clearly, let us suppose the Lungs to be so rigid, as neither to dilate nor contract, but with the greatest difficulty.

ON this supposition, before the Lungs will begin to dilate, and take in Air thro' the Mouth and Nostrils, the Air in the Cavity must be dilated, till it becomes as much rarer than the common Air in the Lungs, as is required to give that Air a sufficient Superiority of Force to overcome the Resistance they make against Dilatation; and in order to expand the Air in the Cavity to this degree, the Cavity of the Thorax must be pro-

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portionably

portionably enlarged. And as this must be done before the Lungs begin to dilate, the Muscles which raise the Ribs must at the same Time support and overcome a considerable Part of the Pressure of the Atmosphere, upon the external Surface of the Thorax, as the Diaphragm must that, upon the external Surface of the Abdomen: and consequently, the Chest must in this Case be more dilated, and with greater stress to the Muscles, than it naturally is.

FOR the same Reason, in Expiration, the Air in the Cavity must be compressed to such a Degree above the common Air within the Lungs, that it may by its Superiority of Force overcome the Resistance they make against contracting; and consequently, as remarkable and laborious an Action of the Muscles will be required to diminish the Cavity in Expiration, as was required to enlarge it in Inspiration.

THERE are some Particularities too, worth mentioning, which will attend these laborious Actions.

FOR in Inspiration, the Chest being obliged to be remarkably enlarged, and the Air in the Cavity to be considerably rarer than the external Air; it will follow, that the fleshy Portions between the Ribs, and about the Collar Bones, being pressed much more without than they are within, must be squeezed and dented inwards; and this will be the more visible, the more difficultly the Lungs dilate, and the more emaciated the Person is who breaths.

WHEN Inspiration once is made, the Muscles which dilate the Chest cease to act, and their Antagonists immediately begin. The Instant the first of these cease to act, the superior pressure of the external Air upon the Surfaces of the Chest and Abdomen has nothing to counteract it; and consequently, the Cavity of the Chest must that Instant be suddenly contracted, both on account of the Weight of that external Air, and of the Action of the other Set of Muscles, till the Air about the rigid Lungs is condensed to the same degree with the
external

external Air. Consequently, between the Instant at which the Chest is most dilated for Inspiration, and the Instant at which the Air begins to be expired, there will be a very short interval of Time, in which the Cavity of the Breast will be contracted with a Jirk, as if it was convulsed, without any Air's being expired; an Action we cannot imitate in Health, without forcing the Air out of the Mouth or Nostrils.

It might perhaps be expected, that the fleshy Portions between the Ribs, ought to be as much forced outwards by the superior Force of the internal Air in Expiration, as they are dented inwards in Inspiration; but this cannot happen sufficiently to be observed, on account of the Manner in which the Pleura is connected to the Ribs: A particular Explanation of which may be seen in the Appendix to these Lectures.

ON the same Account, it seems reasonable to believe that between Expiration and Inspiration, there would on this Supposition be just such a Jirk, as was described before, but in a contrary Direction.

WHOEVER is curious enough to satisfy himself thoroughly of the Truth of what is here described, may see most of these external Appearances very evidently, particularly those first mentioned, in the Breast of one in the Fit of a Convulsive Asthma, accompanied with great Pain and Uneasiness. I say, most of these Appearances, because I have here supposed the Lungs equally prevented both from Contracting and Dilating; whereas it may happen that a Disease which prevents their Dilating, may make them Contract more readily, than they would otherwise do; and in this Case, those external Appearances only will occur, which depend upon their difficulty of Dilating; & *vice versa*.

Is it not reasonable therefore to conclude, that the Nerves are in that Asthma so affected as not to lend their Assistance in Dilating the Lungs? and consequently, that there are some Muscular Fibres in the Lungs, which in a healthy State assist and hu-

mour the Action of the other Parts, so as to make them more ready to dilate and contract, than they would be without them?

SINCE these are the Symptoms, which necessarily follow upon any great difficulty the Lungs have of Dilating and Contracting; they must always appear in a greater or a less Degree, whatever disorder occasions that Difficulty, and according as the Difficulty is greater or less: And consequently, from these Symptoms we can only conclude that there is such a Difficulty in a greater or a less Degree, but not from what particular Disorder it arises. For this we must have recourse to other Symptoms, which may accompany these: but there are such a Variety of them, and their Combinations are so numerous, that there are hardly two Cases ever met with exactly alike: It would therefore be endless to endeavour to particularise them all with accuracy. It will be sufficient to reduce them to certain Classes, and even this will lead us to a considerable Length.

THE LUNGS may be prevented from dilating and contracting with perfect ease and freedom, both externally and internally. They may be prevented externally, First, by adhering to the Pleura; and Secondly, by a quantity of extravasated Fluid taking up a Part of the Cavity, and not allowing them room to play.

FIRST, As to the AdhæSION of the Lungs to the Pleura. This is so common a Case, that I believe the Number of those, who upon Dissection are found with AdhæSIONS, greatly surpasses the Number of those without them; but then these AdhæSIONS are of small extent, except in very diseased Bodies.

WHILST the AdhæSION is thus of a small Extent, and the Body is in a tolerable degree of Health, the Lungs are able to play with sufficient Freedom; and Respiration is but little disturbed by it. But when it has spread itself to a great Extent, and the Lungs and Pleura are inflamed, it not only greatly interferes

interferes with the Action of Respiration, but encreases the Distemper itself.

IN this Case, the most certain Symptom to determine us that there is such an Adhæſion, is the Patient's being able to lie on one Side only without Pain, and with tolerable Ease in Breathing; and the Adhæſion is always on the Side, on which the Patient lies with Ease.

FOR, first, when the Patient lies on the opposite Side, the Weight of the whole Lobe that adheres, acts in a Direction to tear it away from the Pleura; whereas, when he lies on the same Side with the Adhæſion, there is no such Endeavour towards Separation.

AND, secondly, when there is an Adhæſion, and the Parts are inflamed; the Action of Respiration should, for the Ease of these Parts, be carried on by a freer Motion of the Ribs on the other Side; but when the Patient lies on that other Side, his Posture not only prevents that Side from relieving the other, by preventing the free Motion of the Ribs he lies on, but even obliges the diseased Side to perform the greatest Part of the Action of Respiration: which must necessarily rather encrease than alleviate the Pain and Uneasiness in Breathing.

SOMETIMES there are Adhæſions on both sides the Breast, which for the same Reasons give little or no trouble in Respiration, before some other Disease of the Lungs or Pleura arises; and when this Disease produces an Inflammation or Impostumation, one Side is generally speaking more affected, than the other; and consequently, very nearly the same Symptoms will appear, as when the Adhæſion was on one Side only.

IN Lungs which have been diseased for a long Time, the Adhæſion gradually spreads, and sometimes becomes universal. This is a Case I have myself seen more than once, and requires our Attention.

FOR

FOR to allow the Possibility of an Universal Adhæſion of the external Surfaces of the Lungs, on both Sides the Mediastinum, to the Parts which are immediately next them, amounts nearly to the same Thing as to allow that Respiration may be carried on, and Life supported, tho' there be no Air in the Cavity of the Thorax; and seems to be giving up the Necessity there is for the Existence of Air there, and the Uses of it; which have been so much insisted upon in these Lectures.

NOTWITHSTANDING this, I make no doubt but the Experiments of Dr. *Hales's*, mentioned in the First of these Lectures, together with the Last of Dr. *Houſton's*, which I shall consider in the Appendix; must convince any impartial Reader, that there always is a Quantity of Air contained in the Cavity of the Breast of every one, who breaths freely and easily, without being soon out of Breath upon using moderate Exercise.

UPON the Strength of these Experiments, therefore, let us take it for granted, that there is Air originally in the Cavity, and and see what the Consequences will be of too great or too little a Quantity of it, or none at all.

IT is difficult to determine, whether the Air is in the Cavity, from the very first Formation of it, or whether it passes thro' the Lungs upon our first endeavouring to breath; as we may see from an Experiment of Dr. *Hales's* it will very easily do. However this be, if there should ever be so little Air in the Cavity, as to be much rarer than the common Air at the end of Inspiration, when the Lungs are distended every where as much as they are accustomed to be; we see by that Experiment, that the Air will force its way thro' the Lungs, and supply that deficiency. But for the same Reason, no more Air will ever pass thro' them, than what is just sufficient to make the Air in the Cavity very nearly of an equal Density with the Air in the Lungs, when they are as much dilated, as they usually are in Inspiration.

HENCE

HENCE it appears, that whilst the Lungs are in Health, there is no danger of there ever being too small a Quantity of Air in the Cavity, because the external Air will force itself into it, and supply the Deficiency almost as soon as it happens: Neither is there a Possibility of too great a Quantity of it ever insinuating itself this way into it; because, whenever the Air within the Cavity is at the End of a forcible Inspiration, nearly of the same Degree of Density with that within the Lungs, the difference of Pressure will not be able to force any more Air thro' them.

BUT is there not another Source, whence we may derive the Encrease and Diminution of the Quantity of the Air in the Cavity? Is there not always oozing into this, as well as every other Cavity of the Body, from the exhaling Vessels of all the Parts that form it, or are contained in it, a warm fine perspirable Matter? and is not this Fluid as constantly imbibed and carried away again by the absorbing Vessels of the same Parts? May not this Fluid, like all other Vapours, sometimes generate Air, and sometimes absorb it? and consequently, sometimes encrease, and sometimes diminish, the quantity of Air in that Cavity?

WITH regard to the Encrease of Air; if too great a quantity of it be generated of a sudden, will not the Consequence be, preventing the Lungs from dilating sufficiently for the Blood to circulate freely thro' them, without a laborious Dilatation of the Breast in Inspiration? And must not this Symptom immediately cease upon this Air's being absorbed and taken up again by that Fluid? May not this be the Cause of some of those sudden difficulties in Breathing, to which Hysterical and Hypochondriacal People are liable, who abound with all manner of Flatulencies? This seems to be impossible for us ever to determine with any certainty.

BUT

BUT with regard to the Deficiency of Air in the Cavity; it is certain in general, that the Consequence of an absolute Vacuum there is, that every Part contained in the Thorax must at least be closely applied to, and pressed by, the whole Weight of the Atmosphere against the Parts which surround them; and consequently, the less the quantity of Air the more extended will the Application be of Part to Part; the more will the Lungs be dilated, even in Expiration; and the more will the Diaphragm be pressed up into the Cavity, even in Inspiration. Now a close Application of one Part to another, is the first Step towards their Adhæring, provided they did not adhære in the first Formation. The Want therefore of a due Quantity of Air in proportion to the Magnitude of the Cavity, and the Size of the Lungs, must necessarily bring on at first an Application of some one Part to another; which in Time, or upon the Lungs or Pleura growing diseased, will lead the way to an actual AdhæSION: And since the Lungs when they are much diseased, are too much stuffed up to allow a Passage for the external Air to get into the Cavity and supply the Deficiency; and since the remaining Air may be absorbed by the Vapour in the Cavity: the Quantity of Air there may on these Accounts be continually diminishing, and consequently the AdhæSION continually spreading, till at last it becomes universal.

THUS do we see, that the natural Consequence of supposing the Air to decrease gradually, till at last there remains none at all in the Cavity, will be first a partial, and afterwards an universal Application, and at last an universal AdhæSION of the Surface of the Lungs to every Part about them; which no one I believe ever saw upon opening a Patient of his own, without accounting from it for all the bad Symptoms, which had attended his Breathing at least, if not for his Death itself.

SINCE

SINCE then the Absence of Air must evidently bring on so remarkable a Disorder in the Organs of Respiration, would it be unreasonable to assert that there is always Air in the Cavity of those who breath with perfect ease, even tho' we had no Experiments to confirm us in that opinion; and to allot it this Office, amongst others, of keeping the Contents of the Thorax from being continually applied together, and so preventing the first Cause of their adhæring? But when every Experiment, that has been made, seems to favour this Opinion, we can no longer hesitate about it; tho' we know no other Way of accounting for the Time a Person lives, whose Lungs adhære universally, than by observing that a very small Dilatation and Contraction of the Lungs will be sufficient barely to support Life.

BUT there is a Disease of the same Sort, which when it happens at the same Time, with an universal Adhæsion of the Lungs to the Parts about them, must greatly encrease the Symptoms of it; and this is an Adhæsion of the Pericardium to the Heart: in which case the Motion of the Heart must be interfered with, as well as that of the Lungs.

I shall now lay before you an Instance of each of these Cases, and an Account of the Symptoms, which attended them.

— *Hughes* was taken into the Infirmary in *June 1739*. The only Complaint he made, was of a most intolerable Pain, as he expressed it, in the Pit of his Stomach, which tormented him without ceasing, and had done so for a considerable Time. He was Feverish, his Face looked flushed, and he seemed worn down with Pain. His Pulse was quick and low, but regular. He had a little Cough without expectorating any thing.

THIS Pain continued upon him near a Month, notwithstanding all the Methods we could contrive to give him Ease, yielding only for a Time, when he was suffered to take large doses of Laudanum; and seemed at last to go off of itself, ra-

ther than by any Medicine ordered him at that particular Time. Soon after this, his Cough encreased with large Expectoration, he fell into Loofenesses and cold Sweats, his Strength and Flesh decayed, and he was forced to keep his Bed. In this Way he lived, spitting continually a large quantity of Matter, with alternate returns of colliquative Sweats and Loofeness, till in *September* he died. He had no great Pain, nor any very considerable difficulty in breathing, more than others have, who have large Impostumations in the Lungs.

UPON opening his Body, we found a total Adhæfion of the Lungs, to every part about them, on both sides; the Pericardium remarkably larger than is usual, with a great quantity of Fluid in it; and the Lobe on the Left Side ulcerated and full of Matter.

J. M. Coachman, who had almost from his Infancy been accustomed to hard Labour, as well as the Drinking of Spirituous Liquors to excess, in the beginning of the Winter, 1734, was seized with a Cough, which he neglected, till it turned Consumptive. At the Time that I was applied to for my Advice, he was reduced to the very last Stage of a Consumption, and was confined to his Bed with the following Symptoms. He had a great Difficulty in Breathing, and Pain in his Sides, so as not to be able to lie down in his Bed; a violent Cough, which hardly ever ceasing deprived him of his Rest; Colliquative Sweats, and Loofenesses, which took him alternately; and an Expectoration, which resembled Matter, by every trial we could make. His Pulse was quick and low, but regular; his Nose was sharp, his Shoulders *vere alati*, and his Eyes had the true Consumptive sharpness.

By Bleeding twice or thrice, to the quantity of five or six Ounces at a Time; by easing his Cough with Pectoral Drinks, with Nitre and gentle Opiates in them; and by palliating his Loofenesses and Sweats as occasion required; I got him so much rest
and

and strength, that he was prevailed with to be set on Horseback, when he could not ride without being held on his Horse. He began with riding only once up and down the Street he lived in, but in a very little Time was able to go out by himself, and ride an Hour or two. This agreed with him so well, and he recovered so fast, that he took a Resolution, which he kept to his Death, of confining himself strictly to a Milk-diet, and riding out every Day, let the Weather be what it would.

IN about two Months Time after riding on Horseback, his worst Symptoms had almost left him, and he had occasion for no other Medicine, than a gentle Opiate at Night to keep what little Cough he had from breaking his Rest, and the Elixir Vitrioli Lond. 50 or 60 Drops of which he took twice a Day, for near three Quarters of a Year, notwithstanding his Milk-diet, without finding any Inconvenience from it.

IN this manner he lived all the Summer 1735, towards the end of which his Spitting and Sweats entirely left him, and his Body was rather bound than otherwise, so that he left off his Drops, and took nothing but the Elect. Lenitiv. occasionally. All the Winter and Summer following he continued well, without any other Return of his bad Symptoms, but what yielded soon to repeated Bleedings in small Quantities at a Time. He now began plainly to recover his Flesh and Strength, and being able to ride 20 and sometimes 30 Miles in the Day, imagined he was equally able to return to his Business. But Driving required too much muscular Exercise, and he had like to have fallen off his Box for want of Breath. In the same Manner he was soon out of Breath upon walking fast, and was thrown into a Fit of Coughing, whenever he attempted to do it. Otherwise he had hardly any Cough at all.

THUS did he live for near three Years from his first getting on Horseback, still following his Milk-diet and his Riding, till in the last half Year, his Flesh began to fall away again, and

his Breathing became so difficult, that he could not bear even the Exercise of Riding, without being ready to drop off his Horse. This Symptom encreased apace upon him, and soon confined him to his House, where he grew so bad, that he could not trust himself to walk the Length of the Room, without somebody by him to catch him in case he should fall.

IN this last State he lived without any colliquative Sweats or Looseness, or Expectoration, which generally attend so great a Decay. Nothing gave him any relief, when he was in extremity, but Bleeding in an exceeding small Quantity, and this only for a few Days. He tried it indeed but twice in this his last Confinement, because tho' his Pulse was quick and regular, it was low and thready, and he was excessively weak. He died at last without Pain, or any great Uneasiness, except on the slightest Motion, which always brought on a short dry Coughing for a few Minutes, which he could hardly bear without sinking down in his Bed.

MR. *Middleton* opened his Body. Upon viewing it before it was opened, we both of us observed, that the Abdomen was shrunk inwards, as remarkably, as it is in the most forcible Expiration. Upon opening the Thorax, we found the Diaphragm remarkably squeezed up into the Cavity, the Lungs perfectly sound and entire, but every where adhæring so strongly to the Parts about them, that they could not be separated without tearing. The Lobes on the Right Side adhæring every where, strictly speaking, to the Pleura, Mediastinum, and Diaphragm; and on the Left, to the Pleura, Mediastinum, Pericardium, and Diaphragm. But what was most remarkable, was that the Pericardium adhæred every where both withinside and without; withoutside to the Lungs and Diaphragm; and within to the Surface of the Heart, every where but just at the Bottom, and so strongly, as not to be separated without tearing. It seemed indeed to adhære to it by Fibres. At the Bottom there was a
gelatinous

gelatinous Substance, which was in all probability the Remains of the Fluid, which is found in the Pericardium, squeezed into a Space no bigger than one's little Finger along the Tip of the Heart. This Substance from one side to the other along the extream Edge of the Tip of the Heart was of different degrees of Consistency, so as at one end to be as soft as a common Jelly, and at the other quite Membranous; and in the intermediate Space, gradually tending from the Consistency of a Jelly to that of a Membrane, as might be seen by beginning Fibres in the softest Part of it, which were thicker set, and more perfectly formed, as they approached the Membranous part; so that the whole Cavity of the Thorax was filled up by its Contents, without any space left for Air.

THIS Case I have related at large, with the most material Circumstances, because the Appearances upon opening the Thorax, were as remarkable as his Recovery, and Living for more than three Years, after his being reduced to so low a Condition; and after so noble a Part, as the Lungs, was so much diseased.

DR. Lower mentions a Case in his Treatise *De Corde*, in which the Pericardium was found adhæring to the Heart, whilst the Lungs hung freely in the Cavity.

“ Uxor cujusdam civis Londinensis, Ætat. 30 Annorum,
 “ olim satis sana, & alacris, per tres ultimos vitæ suæ annos mæsta
 “ valde, & melancholica, porro et ad motum quemvis anhela,
 “ cum pulsu parvo, & *semper intermittente*, de dolore insuper
 “ cum insigni gravamine præcordia infestante continue fere
 “ querebatur; quin et crebris lipothymiis, & a levi quovis corporis
 “ motu spirituum deliquiis, & extremorum infrigidationi
 “ obnoxia demum evaserat: in quo statu a nullis medicamentis
 “ juvata tandem, viribus sensim attritis, interiit. Cadavere aperto
 “ circa viscera inferioris ventris nulla omnino vitia apparebant;
 “ dum verò alias partes perscrutamur, cordis affectionem depre-
 “ hendimus

"hendimus in quam omnium malorum causas merito referamus.
 "Thorace enim aperto, pulmones satis sani fuerunt, Cordi
 "tamen toti Pericardium ubique adeo arcte accreverat, ut digitis
 "non nisi ægre ab illo separari potuerit; porro hæc membrana
 "non, uti oportuit, tenuis, & pellucida, sed crassa, opaca, et
 "velut callosa evaserat: hinc cum nulla intercapedo pro libero
 "cordis motu, et nulla, quâ humectaretur, aqua adfuerat, nihil
 "mirum si de malis his omnibus continuo quereretur. Præterea
 "cum Pericardio Humano Diaphragma semper accrescat, ubi
 "Cor ipsum quoque pericardio uniri accidit, fieri non potuit,
 "quin in omni inspiratione Cor etiam secum deducere, adeoque
 "motum ejus tam diu sistere, & suppressere necesse habuit:
 "unde pulsus ista intermissio *omni inspirationi* perpetuâ vice
 "tam constanter succedebat."

I have transcribed this Case from Dr. *Lower*, because of the Symptom of the intermitting Pulse, which he makes a necessary Consequence of a total Adhæsion of the Pericardium to the Heart, and which, notwithstanding, I am certain was so far from being constant in *J. M.* or following every Inspiration, that I do not remember ever once to have perceived it; and therefore it cannot be the necessary Consequence of such an Adhæsion.

As to the two Cases I have related; does it not seem reasonable to believe that the healthy State of the Pericardium in the one, and the diseased State of it in the other, were the Occasions of the different Symptoms, which attended their Breathing, tho' in both the Lungs every where adhæred strongly to the Parts about them? Is there not Air, as well as the watery Fluid, within the Pericardium? Must not this Air be always equally dense with that in the Cavity, or with the Air in the Lungs? And since the Lungs in a healthy State, expand themselves immediately into the Room made for them by the dilating of the Chest, and immediately contract when the Chest contracts; does the Air in the Cavity ever vary much in its degree of
 Density,

Density, in the Actions of Respiration? Must not the Air in the Pericardium therefore continue at all times nearly of the same degree of Density likewise? Will not this Air therefore constantly keep the Pericardium very equally distended, and allow the Heart the same Space, and Liberty of Beating at all times? But further, if there is no Air in the Pericardium, there must either be Fluid enough in it to distend it equally every where about the Heart, or not. If there is, then the Heart must beat with the same Difficulty, as if the Pericardium adhæred, and its Substance were thickened, so as to take up the same Space, as the Water does: and if there is not Fluid enough to fill it, the Part not filled must by the Pressure of the Air, or the Parts about it, be squeezed close, and kept always applied to the Heart itself; which will bring it to the same Case, as if it adhæred. And consequently, the Pericardium with its Fluid would be of little or no service towards the Ease and Freedom with which the Heart beats. What I have here said I only propose, as worthy of further Consideration.

WAS it not the Largeness of the Pericardium, and the Quantity of Fluid there, which made *Hughes*, tho' his Lungs every where adhæred, nay tho' one Lobe was quite impostsomated, breath with more ease even to his Death; and bear ordinary Motion so much better than *J. M.* by affording the Heart room to dilate and contract, in proportion, as more, or less Blood was to be circulated by it in the same Time? May it not be supposed that the Pericardium did not begin to adhære in *J. M.* till very near the Time of his Death; and that as that Cohæsion spread, he grew worse, and less able to bear motion; till at last when it became universal, he could not move at all, without being in danger of the Circulation being entirely stopped, from the Heart's not being able to dilate but to one certain degree? and was not this at last the occasion of his Death?

AND

AND from the Whole is it not reasonable to conclude that a quantity of Air in the Cavity is necessary, in order to perform the Action of Respiration with perfect ease and freedom? That Respiration may be tolerably carried on, when the Body is otherwise in Health, when there is a partial Adhæſion? That Respiration may be sufficiently carried on barely to support Life, when the Adhæſion is total, but not ſo as to undergo any Exerciſe? That when the Pericardium adhæres to the Heart, as well as the Lungs to every Part about them; the very ſlighteſt Motion imaginable cannot be performed without danger of Suffocation? And conſequently, that the want of Air in the Cavity of the Breſt, is one great Impediment to the Freedom with which the Lungs ought to play :

SECONDLY, it is eaſy to ſee that any extravasated Fluid lying in the Cavity of the Breſt, muſt by its weight upon the Diaphragm, as well as by taking up room there, greatly interfere with the Action of Respiration.

COLLECTIONS of Water have been found ſometimes in one ſide only of the Cavity, ſometimes in both, and ſometimes within the Duplicatures of the Mediſtinum. In any of theſe Places, it prevents a free Respiration, but moſt when it lies on both ſides.

IN Dropſical People, where the Belly is much diſtended; it is very hard to determine from any difficulty or interruption in Respiration, whether there is Water in the Cavity of the Breſt, or no; becauſe the Tenſion of the Abdomen, as was ſhewn above, muſt interfere with Respiration; and as Dropſies are moſt frequently brought on by a Courſe of hard Drinking, in which Caſe the Lungs are generally diſtempered themſelves, and adhære to the Pleura, it will on this account be ſtill more difficult. There ſeems indeed nothing to determine it by, with any certainty, but the Patient himſelf feeling ſomething move in his
Breſt.

Breast like Water, upon a sudden change of his Posture in Bed.

I was once present at the opening of a Dropsical Man, when from the Symptoms, which attended his Disease, we were all so certain of there being Water in one side of the Breast, that our design in opening him was only to see, whether the Water was contained in that side, on which he could lie with tolerable ease, or on the other, on which he could not bear to lie at all. On opening the Thorax, there was not a single drop of Water to be found; but there was almost a total Adhæsion of the external Coat of the Lungs on both sides to the Pleura, and an extended Inflammation, together with numberless small Ulcers in one Lobe, just where it adhæred to the Pleura. This was enough, together with the quantity of Water in the Abdomen, to account for all the Symptoms, which related to his Breathing; and sufficient to make us more upon our guard in our future determinations about an *Hydrops Pectoris*.

AN extravasated Fluid of any kind whatever will disturb the Action of Respiration by its weight and bulk; but when that Fluid is of a Nature to corrode, and contaminate the Parts about it, as Matter is when it begins to putrify, it will have much more pernicious Effects.

WE ARE, in the next Place, to point out the different Springs, from which the internal Disorders of the Lungs arise, which prevent their dilating and contracting with that ease and freedom, with which they play in Health.

FIRST, the Construction and Distribution of the Pulmonary Arteries and Veins, and the uninterrupted Circulation of the whole Mass of Blood thro' their minutest Branches, have been so often mentioned in the Course of these Lectures, that they need not be repeated, to convince any one of how fatal a Consequence any great Obstruction, Inflammation, or Breach of any

of these Vessels, must necessarily be even to Life itself, or how greatly it must disturb Respiration in particular.

SECONDLY, The Aspera Arteria, Bronchia and Vesicles, the Coats of the Pulmonary Arteries and Veins, and in short all the Substance of the Lungs themselves, is in every part supplied with Nourishment by Arteries, and the superabundant Fluid is carried back by Veins, which arise from different Springs, terminate in different Channels, and are entirely independent of the Pulmonary Arteries and Veins.

THE Lungs, therefore, are liable to Obstructions, Inflammation, Pain and Impostumation, with their Train of Symptoms, from this System of Vessels, as well as from the former; and the Pain, Uneasiness, and Difficulty these Disorders will occasion in the alternate Dilatation and Contraction of the Lungs will disturb and interfere with the Action of Respiration.

FROM these Vessels, there frequently happen Hæmorrhages, especially in the Branches distributed about the Windpipe; which as the Blood must descend into the Lungs before it can be discharged, and consequently must be thrown up by Coughing, will have the frightful Appearance of coming from the Pulmonary Vein or Artery; but will neither interfere with Respiration so much, nor be attended with the same Danger, as a Hæmorrhage from a Breach in those Vessels.

THE Blood, which is coughed up in this Case, is always observed to be more florid, than that which proceeds from a Breach within the Lungs themselves; and the Reason seems to be this, that whilst it trickles down the Windpipe, or Bronchia, it's Surface is as much exposed to the Air, as when it is immediately caught in a Porringer from the Arm; which is not true in the other Case.

THIRDLY,

THIRDLY, Tho' the Blood does in a great Measure owe its nutrimental and beneficial Constitution, when the Body is in Health, to the Action of the Lungs; yet as there is nothing particular in their Action, different from that of the other Vessels of the Body; it will follow, that unless the Chyle, which is to be mixed with the Blood, be brought to the Lungs in proper Quantities, and endued with proper Qualities; unless the Discharge thro' the Sides of the Vesicles be regularly and duly performed; unless a proper Quantity of Air-Particles be absorbed, to supply the active Principles so necessary to the Warmth of the Blood, and the Cohæsion of its Parts; nay, unless the Arteries of the Body keep up and improve the advantageous Alteration of the Blood begun in the Lungs: it must at every return of the Circulation arrive at the Lungs; and if the same Circumstances continue, pass out of them too, less and less fit for the Purposes of Life. So that by degrees the Blood will be so much impaired and broken, that when it most wants the Assistance of the Lungs, it will be brought thither when it is only fit to choak up and clog the Vesicles and Capillary Arteries, so as to prevent the little Service it could receive in passing once thro' them.

THUS may the Blood itself, when it is once become of a broken and vitiated Constitution, be the Occasion of many different Interruptions of Respiration, and of many Diseases in the Lungs, as well Chronical as Acute, and may at last put a stop to every Action designed by Nature, to preserve it of a healthy and arterial Constitution.

FOURTHLY, The Vesicles of the Lungs are, in a healthy State, continually discharging out of their Cavities what recrementitious Vapours are continually oozing from the Blood into them, and receiving in their stead a fresh supply of Air. If therefore either these Vapours, or those in the Air itself, are suffered to lodge there, thro' any accidental disorder or difficulty in the Action

of Respiration, their more fluid Parts evaporate; and those that remain condense, concrete, and perhaps corrode, at best clog, and render useless, the Lobule composed of these Vesicles; and it is seldom that these ill Effects stop, without in the same manner affecting a whole Lobe.

THE same, but more fatal, will the Consequence be of an Obstruction, Inflammation, and succeeding Suppuration in the Capillary Arteries distributed about the Sides of these Vesicles; because such a Disorder is not only more violent, but more likely to spread, and contaminate the neighbouring Lobules, till it has destroy'd the whole Lobe.

NATURE, indeed, has been very careful to avoid the spreading of any such Disorders, by the many Partitions she has made, and the many Divisions of the Lungs into separate Lobules, encompassing each with its particular Membrane: And whenever any Obstruction is threatned in any Part, the Number of Inosculations among the Arteries in the Lungs is most wonderfully contrived to carry the Blood thro' other unobstructed Passages, so as not to encrease the beginning Malady; and the inner Surface of all the Air-Vessels is thick set with Glands, which distill an oily Fluid to facilitate the Expectoration of any obstructing Matter, that can be thrown off, by keeping those Vessels moist and glib.

BUT notwithstanding all this industrious Contrivance to preserve the Lungs; when the Solids of the Body are weak, either thro' a natural Constitution, Irregularity, or a long Series of other Distempers, the fine Contexture of the Vesicles naturally exposes them to these fatal Obstructions.

FIFTHLY, These Glands, thus dispersed about the Air-Vessels of the Lungs, when they are any how disordered, will disturb Respiration, and may bring on very dangerous Diseases.

WHEN

WHEN the Glands secrete either too great or too small a Quantity of their Fluid, the Vessels that Fluid was only to keep moist and smooth, must either be dry for want of it, or loaded and clogged up by too much; and when those Glands pour out an acrid and corroding Fluid, or grow hard and scirrous, as they frequently do in scrofulous Habits, it is easy to see what irksome Disorders they will necessarily produce in the Lungs themselves.

SIXTHLY, The Membrane that separates the Lobules from each other, is the same Cellular Membrane, that divides all the other minute and distinct Parts of the Body from each other. This is so certain a Fact, that the whole Body of the Lungs may be dilated by blowing Air thro' a small Pipe into the Cells of this Membrane, without any of it escaping into the Vesicles, Bronchia, or Windpipe. As the Cellular Membrane in other Parts of the Body is known to be the Seat of one sort of Dropsy, and to be then filled with Water; may we not conclude that this in the Lungs may be in the same Manner liable to a Dropsy? Will not such a Condition of this Membrane prevent a sufficient Dilatation and Contraction of the Lungs for an easy and free Respiration? Will not such a Disorder be attended with all the Symptoms of an Asthma? Do we not, in confirmation of this, sometimes observe an Asthma go intirely off, upon the Swelling of the Legs? Does not the Asthma return, upon that Swelling's disappearing? Have not each of these happened several times to the same Person? Is not the Swelling of the Legs occasioned by a Translocation of the Water, from one Part of the Cellular Membrane, which is every where about the Body, to another? Have we not known Blisters on the Legs sometimes relieve the Asthma? May not we conclude from thence, that the Cause of the Disorder was Water in the Membrane; and tho' the Relief is generally but for a small Time, and the
Symptoms

Symptoms return, may not this happen from too great a flow of Watery Fluid to that Membrane, to be drained off that Way? However this be, this Membrane is certainly the Seat of Impostumations in the Lungs, as it is all over the Body.

SEVENTHLY, The Air it self has so great a Share in the Action of Respiration, and is so necessary likewise to the Health and Vigour of the whole Body, that no remarkable Alteration can be made in it, without our being very sensibly affected by it, especially when our Lungs have been weakened or disordered before.

ELASTICITY is the Principal Quality in the Air itself, upon which Respiration depends; for without it, the different degrees of Heat could not produce that Circulation and change of Air within the Lungs, by which the perspirable Fluid is so constantly carried off in Breathing: And for the same Reason, the Coolness of the external Air is likewise necessary for this purpose; because, if that were equally warm with the Air within the Lungs, that Circulation would immediately cease.

CONSEQUENTLY, when the Air we are to breath is loaded with Vapours, which render it too warm, or destroy its Elasticity, or both; it becomes unfit for Respiration, and interferes with the Action of Breathing.

As the Air enters into the Composition of all the Variety of Bodies, that we know; so in return it receives and supports, and carries along with it all the Exhalations, which can any ways fly off from Vegetable, Animal, and Fossil Bodies. Nay, those particles of Air, which have lain absorbed within the most solid Bodies, and afterwards recover their Elastic State, and mix with other Air again, are not without reason imagined to carry along with them Particles of the Bodies to which they were before so closely connected.

IN different Seasons of the Year, therefore, the Air must necessarily receive different degrees of Warmth from the Sun, and be filled with Vapours, both of different kinds and in different quantities.

AND according to the accidental Circumstances of the Situation of any particular Place, will the Air about it in the same Manner be more clear and healthy, or more loaded with pernicious and unwholesome Vapours.

AND as different Winds blow from the several Corners of the Earth, the Air brought by them will partake of the Nature of the Climates it passes thro', and be loaded with Vapours accordingly.

HENCE, we may easily see what a variety of Disorders in breathing may arise from this Spring, in those whose Lungs are weak, or have been formerly disordered in different Manners; and how differently these accidental Alterations in the Air may affect the Action of Respiration in different People.

BUT this is not all. For as a considerable Quantity of the Particles of the Air is taken in and absorbed by the Blood, and circulated with it all over the Body; the Constitution of the whole Mass of Blood, and the Health of the whole Body, may be affected by the particular Constitutions of the Air; even tho' it has Coolness and Elasticity enough not to interfere with the Action of Respiration.

HENCE, therefore, may proceed those particular Disorders, which are confined to certain Tracts; and those, which every now and then are found to rage for a certain Time; even amongst those whose Lungs are sound and healthy.

HENCE too it may be seen how reasonable Dr. Sydenham's Opinion is, that some Seasons bring with them particular Constitutional Diseases, to which every one is liable; which may not indeed always appear attended with the same Train of Symptoms, but which ought always to be regarded by
every

every Physician in the Cure of almost every contemporary Disease: Because, tho' the Air may not be loaded with Vapours of so noxious or pestilential a Nature, as immediately to affect every Constitution alike; yet it may be so constituted as to work slowly upon the Blood, and dispose it more or less, as every one's particular Constitution is stronger or weaker, towards the same unhealthy State. And according as any one particular Person has at that time made an unguarded use of the Non-Naturals, or as his Constitution is naturally more liable to one sort of Distemper than another, the latent unhealthy Constitution of the Blood will shew itself in this or that Shape, attended with different Symptoms: which will without doubt yield more easily if this be attended to, than if it be overlook'd, and the Distemper be treated in every Season exactly in the same Manner.

IT is very certain that the same Disease, or rather the same Train of obvious Symptoms, will not admit of the same Method of Cure in different Climates; and that the Physician, who attends most to the Nature of the Climate, and the Distempers most frequent there, will with more ease get the better of any particular Disorder, than one who is entirely unacquainted with it, or, which is the same Thing, who neglects taking it into consideration. And why should not the same hold equally true in the present Case?

THIS Opinion therefore of the Doctor's has undoubtedly a Foundation in Nature: and was as undoubtedly the Result of that careful, close, and unwearied Application in observing all the Steps, which Nature takes, not only in throwing off, but even in producing Diseases; for which he is ever to be held in esteem by all of his Profession.

THUS much for the pernicious Effects of the Air in general, as well as with regard to the Action of Respiration in particular.

EIGHTHLY,

EIGHTHLY, Besides these sorts of Disorders, as the whole Substance of the Lungs, as well as the other Parts subservient to Respiration, are supplied with plenty of Nerves; these, as well as every other part of the Body, must be affected by the strange and sometimes fatal Disorders of weak and distempered Nerves.

As to the Manner, in which the Nerves occasion the Action of the Muscles, we are absolutely in the dark. All we know is, that without their Assistance no part whatever can perform its Office; and that when the Body is in health, and the Spirits no way affected, the Natural as well as the Voluntary Motions are duly and properly performed. But whenever the Nerves are so disordered, as no longer to obey the Directions of the Will, or perform even the Natural Offices with constancy and regularity, the Muscles to which they are directed, must of consequence be put into Action irregularly, and produce unnatural and involuntary Convulsions; which will be more or less dangerous, as the Part convulsed is of more or less consequence in the Animal Oeconomy.

THESE ARE THE DIFFERENT SPRINGS within the Lungs themselves, whence the many Disorders arise, to which that useful Organ is liable, and which are all of them in different degrees attended with an uneasiness and difficulty in breathing, and a laborious Action, equally perceptible on both sides the Chest, and in both the Sets of Muscles, which are concerned in enlarging and contracting the Cavity of the Breast.

BUT in order to distinguish these Disorders one from another, which can no ways be done from the different Degrees only of this their common Symptom; we must have recourse to a Variety of other Symptoms, some of which attend on one, and some on others, of them.

IT will be sufficient just to mention the two principal Sources, whence these Symptoms arise: One of which is the Difference in the Discharges made from the Lungs, when they are in health, and when diseased; and the Other, the mutual Connexion between the State of the Lungs, and that of the whole Body.

FIRST, It is easy to see that, when the Glands which are dispersed about the Bronchia, or the Lungs themselves, are diseased; when the Lobules are ulcerated, and the Matter broke loose into the Vesicular Cavities; when the Blood-Vessels are broke, either in a small or a large Branch; when either some, or all these happen together; the Appearance of what is expectorated, must vary: and the Variety must be still increased by the different Appearances the same Substance will put on, according as it lies a longer, or a shorter Time before it is expectorated. I have yet met with no Author, who has so carefully and amply described the different Discharges by Expectoration in the Chronical Diseases of the Lungs, as Dr. Bennet has in his *Theatrum Tabidorum*. To him therefore I must refer those who are curious; my Time not allowing me to be particular in their Differences at present.

SECONDLY, When we reflect on the Use of Respiration in the Animal Oeconomy, as delivered in the last Lecture, we cannot but see how strict a Connexion there must necessarily be between the State of the Lungs, and that of the whole Body; so that one of them cannot be disordered to any great degree, without the other's being sensibly affected.

I shall instance only in two Particulars.

FIRST, As the whole Mass of Blood must pass thro' the Lungs, at every Return of the Circulation; every Fever must interfere with the Offices of the Lungs: because in every Fever the Fluids are not only vitiated; but, vitiated as they are, they are hurried with a greater Velocity than ordinary thro' their minutest

test Vessels. And reciprocally, any Disorder of the Lungs, which prevents the due and usual Dilating and Contracting of the Vesicles, upon which a free Circulation of the Blood thro' them necessarily depends, must vary the Velocity, with which the Blood moves in health; and as the other Offices of the Lungs depend likewise upon the same free and alternate Motions of their vesicular Part, the Constitution, as well as the Velocity of the Blood, must be varied likewise; and consequently, the Feel of the Pulse, as well as the Complexion of the Blood, must be varied by it.

SECONDLY, The Health of the whole Body does in a great Measure depend upon the Discharges being duly and regularly made in proportion to what is taken in.

THESE are made by Stool, by Urine, by Perspiration at the Skin, and by Respiration at the Lungs. And whilst the Body is in health, they are made in certain proportions by every one of these Ways: But when any of them are accidentally stopped, Nature relieves herself, by encreasing the Discharge at one, or two, or all the others.

NOTHING will make this more evident, than the Case of a young Man, into whose Bladder no Water passed for twenty Days: during which time, he had frequent Sweats, strongly impregnated with Urine; he had the Smell and Taste of Urine in his Mouth and Nostrils, which must certainly have arisen from the Vapours taken up, by the Air in the Lungs, in Respiration; and besides this, he had regularly every Day two, and sometimes three, watery Stools of near a Pint a-piece, which had all the Appearance of sheer Urine. The Fæces Alvi came away every Morning pretty solid; and the Urinous Stools in the Day time, most commonly without any mixture of the Ordure. He is now alive, and makes his Water regularly, but is subject to Relapses upon taking Cold. Towards the End of the twenty Days, he was seized with Epileptic Fits, which he has not quite

got rid of, but they are much milder than they were. In such Suppressions of Urine, the Smell of it in the Nostrils about the 7th, 9th, or 11th Day, is mentioned by Authors, as a fatal Symptom; and there is scarce an Instance given of any one, who survived the thirteenth Day: But, as there is no one that I have met with, who takes any notice of Urinous Stools, I am apt to believe this young Man was saved by Nature's being able to throw off the Load into the Bowels, which had not happened in the Cases refer'd to by those Authors.

IN the same Manner, when Perspiration is obstructed at the Skin, more especially in a costive Habit of Body, that Office is more remarkably carried on by the Lungs: and when this Endeavour of Nature to throw off the perspirable Matter of the Lungs is obstructed, either by their being weak, or diseased, or overloaded with Vapours; there arises a Cough, a stronger Effort to remove these Obstructions, and the Urine is loaded with a remarkable Sediment; which are the most common Symptoms of what we call a Cold: which generally goes off, either with a free and large Expectoration, or a Return of Perspiration at the Skin in kindly Sweats, or a gentle Looseness. All which are agreeable to what is here laid down.

AND when the Lungs are so diseased, as not to be able to suffer so considerable a Discharge to be made there, as is required; that Office is performed for them in the Bowels, and at the Skin. And as in Consumptive People, the Lungs continue in this State for a long Time; the Pores of the Skin, and the exhaling Vessels in the Bowels, are by constant use and the habitual Flow of the Fluids to them, stretched, and enlarged beyond their healthy Sizes; and the Fluids likewise, for want of the Assistance of healthy Lungs, and a strong Circulation, are more attenuated, less equally mixed and blended together, and more apt to run off in large Quantities at these Places, than they are in a healthy State.

HENCE

HENCE it arises, that the increased Perspiration of these Parts, which at first relieves the whole Habit of the Body, must at last weaken, and bring it to decay; by terminating in colliquative Loosenesses and Sweats: And hence it is, that in these Diseases, when one of these Discharges is stopped by the force of Medicine, the other breaks out soon after in a more violent Manner.

THESE therefore are the principal Ways, in which the Lungs and the rest of the Body are mutually affected, so as in a good Constitution to assist each other in removing any accidental Disorder; but in a vitiated one, to join their Forces in hastening the Decay of the Whole.

CONSEQUENTLY, the different Feels and Velocities of the Pulse; the different Consistency and Complexion of the Blood; the different Quantities of the Discharges by Stool, by Urine, and by the Skin; the different Appearances of the Discharge by Expectoration; together with the different external Appearances in the Action of Respiration, described above; must all of them be taken into consideration, when we undertake either the Cure, or the Theory, of the principal Diseases of the Organs of Respiration.

FOR though, at the Beginning of this Lecture, we supposed, for the sake of Method, and clearness of Conception, the Lungs, and the rest of the Body, every way else in perfect Health, except in the particular Disorders, which came by turns under Consideration; it must by this time be very evident, that this can hardly happen so in fact. The close Connexion among the minute Parts, which compose the Lungs, and the mutual Connexion between their Health, and that of the whole Body, make it next to impossible for any considerable Disorder to befall any part of the Lungs, without the Whole, or indeed without the rest of the Body, being more or less affected.

HENCE

HENCE it is plain, that there are none of these Diseases, so considerable as to be marked out and distinguished by Authors under particular Names, that are not of a complicated Nature; or do not owe their Rise to the Disorders of several Parts of the Lungs; and besides, are not attended with some Disorders of the whole Body.

AND as we have seen that the Disorders of the Organs of Respiration affect the Velocity and Constitution of the Blood, and disturb the Equality of the Discharges, which must necessarily be made to keep the whole Body in a healthy State; and on the other Hand, that Fevers of almost all kinds must interfere with, and disturb, the Offices of the Lungs, and their regular Dilatations and Contractions: it is hardly to be conceived that any such considerable Disorder, as we are now talking of, should happen, without either producing, or being produced by, a Fever of some sort or other.

For this Reason, the Diseases of the Organs of Respiration are divided by Authors into Acute and Chronical, according as there is, or is not, an Acute Fever joined with them.

AND as the Violence of a Fever must not only encrease the Danger naturally attending on any Diseases of these Parts, on account of their Make, Situation, Use, and constant Motion; but must likewise hurry on the most fatal Symptoms in a very short Time; their acute Diseases seem more particularly to require our maturest Consideration: that we may not at so critical a Juncture either order any thing that is improper, thro' the Hurry and Impatience, or neglect any thing that is necessary, thro' the Fear or Prejudice of the Patient, or his Friends about him.

To these therefore I shall confine myself in the remaining part of this Lecture.

It may perhaps be expected, after so long a Detail of the Make of the Lungs, and their Uses in the Animal Oeconomy; and

and so nice an Enumeration of the many Sorts of Disorders to which they are liable; that some Rules might be established, upon which to build the Methods of Cure, so very plain and certain, that when they were once made known, every body might equally make use of them with success. But whoever will consider what has been insisted on in the last two or three Pages, will easily see that the Fever is the first and most material Object of our Care in these acute Diseases, as it is that which so immediately endangers the Life of the Patient; and consequently, that unless some plain and certain Rule were known for the Cure of all the Variety of Fevers, none such can be expected from the Theory of Respiration only, tho' it were supposed to be never so perfect.

LET us however see how far our Theory may be of service to us, by supposing a Person otherwise in Health, and of a good Constitution, to be seized with a violent Inflammation on the external Surface of the Lungs, and that this Inflammation was left quite to itself. Let us likewise suppose, if possible, the rest of the Body no otherwise affected, than it would have been if the Inflammation had happened on the Surface of any of the Limbs.

THIS Inflammation would, like all others, either dissipate of itself, and then the Person would recover; or end in Suppuration. In this Case, the Matter thus made and collected would in time break loose, either into the Air-Vessels of the Lungs, or into the Cavity of the Thorax, or externally thro' the Intercoastal Muscles and Skin, if there was an Adhæsiion of the Lungs, where they are inflamed, to that Part of the Pleura which lines the Ribs.

IN either of these Ways, before the Matter can be discharged, it grows putrid, corrodes, and contaminates the Parts about it; and the Person afterwards lingers out a miserable Life, either by continually Coughing and Spitting away his Lungs piece by piece,

piece, in the first Case; or by artificial Drains in the others, which may be made by the Surgeon, till at last some considerable Blood-Vessel is worn thro', and bursts, and the Effusion of Blood suffocates him.

THESE are some of the fatal Consequences we may easily foresee from our Theory. And from hence we must conclude that we are to use our best Endeavours to prevent the Inflammation from ending in Suppuration; and that, upon the present Supposition, this Inflammation is to be treated, as nearly as we can, in the same Manner as any accidental one on the Arms or Legs.

As Bleeding is found to be of the greatest Service in such external Inflammations, it is very plainly pointed out to us in this; and as the Distance of the Part affected from any large Vein that can be opened, is so great, there is a Necessity of taking away a great deal of Blood before the whole Mass can be sufficiently diminished, for it to receive any Relief.

AND as all topical Applications are denied us, we have only cooling and soft Emulsions to assist our Design, and supply the Place of the Blood thus taken away; and if there happen a teasing Cough, attended with a small Expectoration streaked with Blood, we may give gentle Opiates to quiet, and Linctuses to facilitate the Expectoration.

THIS is in general the Method, which Reasoning on the Make and Situation of the Parts dictates to us, and which Experience has confirmed to be the properest, on our present supposition that the Disease is only an Inflammation on some of the principal Parts among the Organs of Respiration; and that what Fever there is arises only from that Inflammation; and that the Constitution is otherwise perfectly good.

BUT as we know from Experience that, in Fevers, there frequently happens an Inflammation, or Inflammatory Eruption, upon some Part or other, which it is of the worst Consequence to repel and strike in, and which often suppurates; such an
Inflammation

Inflammation may fall upon the Organs of Respiration; in which case, the greatest Danger is threatened, either from our permitting it to impostumate, or attempting to prevent it by such frequent Repetitions of Bleeding, as we see are necessary to that End from the Situation of those Parts. In the first Case, the certain Consequence is a nauseous Chronical Disease, which generally ends in the Death of the Patient; and in the Latter, a great Risque is run in disturbing and interrupting the natural Course of a bad Fever. In this Dilemma, we are to use our utmost Endeavours, and apply all our Thoughts, to manage in a Way between the Two; so as to prevent the Suppuration, without interfering more than is necessary with that Course the Fever would naturally have taken without this Impediment.

WHENEVER therefore a Physician finds a Patient labouring under the Heat, Thirst, and Restlessness of a Fever, and at the same Time violently afflicted with a Pain in his Side, Cough, Difficulty in Breathing, or any other of the Symptoms, which show the Organs of Respiration are disordered; he is diligently to enquire into the Rise and Progress of the whole Disease, and carefully to examine into every Complaint, in order to form a Judgment, whether the Disorders in his Breathing are owing to the Fever, or the Fever to them.

IF it appear evidently, that they arise from the Fever; his next Enquiry ought to be into the Nature and Genius of the Fever itself, independent of the Complaints in Breathing: because tho' the Violence of the Pain, and the great Difficulty of Breathing, must be regarded, and alleviated, yet the Cure of the Patient must in the End depend upon the Cure of the Fever.

AND as it is known by Experience, that there is a great Variety in Fevers; that some will not abate, but rather grow worse, on bleeding, whilst others will hardly yield to any Method without frequent Repetitions of it; that some will be

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greatly

greatly encreased by a warm Regimen, which readily yield to a cooling one, whilst others are so low, as to require the constant Use of the warmest Cordials; that some will not bear even the gentlest opening Physick, without a very dangerous Looseness following upon it, whilst others visibly encrease, unless the Body be kept open by the daily Use of Glysters, or small Doses of Rhubarb; that some will give way at once, as it were to a Charm, on the Application of Blisters, whilst others receive no Benefit at all, but are rather encreased by the Pain and Fatigue they occasion; &c. As, I say, there is so great a Variety in the Nature of Fevers, and the Methods of Treatment they will submit to; and as these acute Diseases of the Organs of Respiration often accompany and depend upon each of these kinds of Fevers; it is impossible for any one general Rule to be laid down for the Management of them: But the whole must depend upon the Judgment of the Physician, formed at the Time from the Circumstances of every particular Patient.

I SHALL, therefore, in the next Place, endeavour to point out the Ways we have of judging in particular Cases, which of the different Methods of treating these Disorders is to be made use of, preferibly to the others; whether it be more advisable to proceed by repeated Bleedings, by the cool Method, by the hot one, or by the Application of Blisters.

THIS I am sensible is a very difficult Task; and perhaps may not possibly be done with sufficient Accuracy, for us ever to frame any certain Rule, by which we may judge at once of the Nature of the Fever, and the particular Method we are to pursue: but I make no Doubt that there may be some Signs pointed out, by which we may at least be directed, when to desist from too obstinate a Pursuit of any of them.

FOR tho' it be confessed to be difficult for us to determine of what sort the Fever is, which attends a Pleurisy, (for example) so soon as the Violence of the Pain, and the Danger of the
Disease,

Disease, requires us to do something; yet if we know that different Fevers make it necessary for us to pursue different Methods, we may be as certain that they will not all be equally relieved by the first or second Steps in the same Method; *viz.* they will not all be equally relieved by Bleeding: And consequently, if Bleeding once, or a second Time, affords little or no Relief; but, on the contrary, if the Pulse falls, and the Strength and Spirits flag, whilst the Pains in the Side and Difficulty of Breathing continue as violent as ever, or nearly so; we may be very certain, the Fever will not admit of this Method, and an obstinate Repetition of Bleeding must be dangerous. This therefore will be a true and proper Mark for us to know, when to desist.

I HAVE instanced particularly in Bleeding, because it is universally allowed to be the very first Step that ought to be taken towards the Cure; a Step, which the Violence of the Pain, and Difficulty of Breathing, absolutely require, in order to prevent their encreasing the Fever to a more dangerous Degree: and because the Operation itself affords us an Opportunity of examining into the Alterations which the Blood has undergone in the Fever; and this, together with the Feel of the Pulse, and the Strength and Spirits of the Patient before and after Bleeding, will greatly assist us in determining whether we are to proceed in the Hot or the Cold Method.

IF the Patient be of a full Habit of Body, with strong Vessels, and the Pulse high, and the Spirits good, both before and after Bleeding, and the Blood of a florid scarlet Colour, with little or no Serum; or very fizy: Bleeding is evidently to be repeated, even to the fourth Time, if the Symptoms require it; and the cool emollient Method to be pursued: And towards the decline of the Inflammation, if the Continuance of the Pain demands it, Blisters may be applied, and generally answer their Design.

BUT if the Patient is of a weak and low Habit of Body; if his Strength and Spirits flag, and his Pulse sinks on Bleedings; and, together with these Symptoms, the Pain and Difficulty of Breathing continue; we have very good reason to believe the Loss of more Blood may be attended with very dangerous Consequences, such as Attacks upon the Brain, Syncope, &c. and we ought to desist, as was said before.

IN these Cases the Blood is generally of one, or other of these very different kinds. It is either very fizy: or has all its Parts broken, dissolved, and blended together; and what little Crassamentum there is, breaks upon the slightest Touch, and mixes with the rest.

IN the first Case, a free Use of the Volatile Salt, or Spirit of Hartshorn, the Volatile Salt of Amber, or such like, repeated every six, four or three, Hours, as Occasion requires, together with warm Medicines, are of the greatest Service, and sometimes give almost immediate Relief. Blisters too may in this Case be applied at the very first sinking of the Pulse and Spirits, as they answer the same Intention with the other volatile Salts. It seems to be from Cases of this kind that Goats Blood, and Horse Dung, merely as containing volatile Salts, or Spirit, have gain'd their Reputation for the Cure of Pleurifies.

IN the other Case, neither Blisters, nor the volatile Salts, seem to afford so much Relief to the Patient, as large Quantities of Acids; such as distill'd Vinegar: together with the warm cordial Medicines, as Mithridate, Confect. Raleigh, &c. At the same Time, a Whey made with the Aqua Theriacalis is a very suitable and beneficial Drink for constant Use.

THESE I only offer as Hints, that may be serviceable in guiding us to the right Method of Cure; by which I mean, the Method most agreeable to the Nature of the Fever which accompanies the Disorders in Breathing, in these acute Diseases:

but

but not with a Design that either of these Methods should be obstinately followed, when either the Pain or the Fever does not yield to us. On the contrary, they should be constantly vary'd, as the Symptoms may require.

BUT that I may not be thought to have advanced what I have said of the different Manner of treating these Fevers, merely on my own Authority, and as the Result only of my own Observation, I shall transcribe a few Sentences from the Works of Dr. Sydenham, where he takes occasion to deliver his Opinion in general of the Manner of judging at what Times his own Method of curing Pleurisies, by quick Repetitions of bleeding in large Quantities, should not be pursued.

“ HANC jam nactus ansam,” says he, “ paucula de eo dicam, quod omnium ore tritissimum est, *Pleuresin* scilicet quandoque ita *malignam* reperiri, ut per eos annos *Phlebotomiam ferri nesciat saltem toties repetitam quoties hic morbus communiter deponit*.”

“ CENSEO quidem *Pleuresin Veram & Essentialem*, quæ ut posthæc dicetur, omnibus annorum omnium Constitutionibus indifferenter infestat, *omnibus indifferenter annis Venæsectionem pariter repetitam indicare*; aliquando tamen accideret, ut Febris ejus anni proprie Epidemica, a repentinâ aliquâ manifestarum aeris qualitatum alteratione, materiam morbificam in Pleuram aut Pulmones libenter deponat, ipsaque febris nihilominus eadem prorsus maneat. In hoc casu, etsi *Venæsectio possit concedi*, ut huic symptomati, si multum læviat, occurratur; generaliter tamen si loquamur, *non multo plus sanguinis symptomatis ratione educendus est, quam febris nomine debuerat educi*, a quâ pendet istud symptoma; namque si hæc ejus sit indolis ut a repetita venæsectione non abhorreat, potest ea repeti in Pleuritide, quæ ejusdem symptoma est; at vero *si febris repetitam Venæsectionem respuat, ne-*
“ *quo-*

“ *que juvabit ista, immo & nocebit in Pleuritide, quæ cum febre stabit cadetve.*

“ Hoc modo autem se res habuit, me saltem iudice, in *Pleuritide Symptomaticâ*, quæ febrem comitabatur hoc in loco grassantem quo tempore subingrediebantur *Tusses*, hac nimirum hieme 1675; atque hoc quidem mihi ideo reticendum non erat, quod existimem dubio illum tramite errare, atque incerte duci filo, qui in febrium curatione non continenter ob oculos habet anni *constitutionem quatenus huic aut alteri morbo Epidemico producendo favet, cæterisque morbis omnibus una concurrentibus in ejus similitudinem ac normam detorquentes.*”

THERE is a remarkable Passage to this Purpose in Dr. *Tabor's Exercitationes Medicæ*, which I shall transcribe likewise, and then conclude.

“ HISCE præterea rebus fidem faciat Febris cujusdam indoles, a nuperis annis, inter harum Regionum Plebeios, admodum funesta; quæ nunc hæc, nunc illâ Anni tempestate oppulariter grassari solita est. E genere erat Pleuritico; Horroribus & Rigoribus exordiebatur ingentibus; qui quo diutius erant protracti, eo infæliciores Ægrotationis prænuntiabant exitum: hisce autem remittentibus, e vestigio excipiebant dextri Lateris dolor acerbus, & haud raro spasmodicus, Virium prostratio insignis, spiritusque difficilis: in Præcordiis porro pondus grave, cruciatusque obtusus sentiebatur. Ut plurimum nec acris erat Calor, nec Pulsus celer aut durus, nec Tussis crebra, nec Sitis ingens, nec liquata nec astricta erat Alvus. Urinæ Crassæ sedimentum non deponentes, colorem habebant stramineum. Vigiliæ pertinaces totum fere morbi cursum comitabantur: Mente tamen constabant Ægroti. Primo quidem sicca erat Tussis; exactis autem præter propter 24 horis, Pituita tenuis non raro, & cruenta expuebatur: postea vero Pituita tum quantitate cum duritie

“duritie auctâ, frequentiores erant, & diuturniores tussienti
 “conatus; usque dum vel a sputo admodum copioso solveretur
 “Morbus, vel a Phlegmate glutinoso intra Pulmones restante
 “strangularetur Æger: quod quidem plerumque ante Diem
 “nonum accidebat; raro serius, sæpe ocyus; *idque præcipue*
 “*si sanguinis detractio intempestive fuisset repetita.* Præ-
 “ter robustos, & plethoricos Juvenes, haud quenquam sangui-
 “nis jacturam sine incommodo pati observatum est: ex iis
 “quidem bis, nonnumquam ter, primis Morbi diebus, sangui-
 “nem educi utile erat; ex aliis autem vel non omnino, vel
 “paucis tantum horis ab accessione instituenda esset Phleboto-
 “mia; quæ etiam exigua summo foret periculo, nisi cito datum
 “esset Medicamentum proritans Vomitus eique validissimo-
 “rum Expectorantium usus succederet assiduus. Ea enim erat
 “Morbi conditio, ad totum Curationis opus a Phlegmate
 “viscido copiose expectorato absolveretur quod (nisi in Ple-
 “thoricis) facilius feliciusque, a Sanguine non misso quam ab
 “ejus dispendio, procederet. Sanguine enim e non Plethoricis
 “educto, Expuitionem suppressi difficilemque admodum &
 “strepitantem Respirationem exoriri, solenne erat: *quo etiam*
 “*sæpius fecabatur Vena, eo magis omnia symptomata intendi,*
 “*eo citius mortem accelerari,* observatum est.”

THERE is no doubt, but those Physicians, who have a large Share of Business, and Numbers in Fevers continually under their Care, acquire a Sagacity, which is not to be taught to others; by which they can more readily and easily judge of the Nature of the Fever, and consequently of the proper Method of Cure, than they who have not the same Opportunity. But this is no Reason why others should not be upon their guard; and endeavour to form to themselves Rules, and Hints for Observation, as well to acquire that Sagacity in Time, as to avoid the most dangerous Consequences of the Want of it at present.

AND

AND tho' these Hints, that I have offered, may appear too general, they are not however to be totally neglected, or despised; because they are equally serviceable in the Treatment and Observation of all Fevers in general, as well as those in particular which are attended with Disorders in the Organs of Respiration; and because they are every where left to the Judgment of the Physician to follow, as the different Combinations of the Symptoms appear most to require.

INDEED the whole Design of mentioning them at all was only to prevent too prevailing a Custom, of treating the same Train of obvious Symptoms always in the same Manner, without considering to how many different Causes they may be owing: A Custom, which owes its Rise to general Names having been given not only to those obvious Symptoms, as if they attended only on one Disease, but to the favourite Medicines too of some Physician in Repute for that Disease; whence those who are learned only in Receipts, are too apt to prescribe to the Name of the Disease, and not to the Disease itself; And the very Opinion, which a Beginner in the Practice of Physick may have formed of the Skill of the Physician he borrows his Receipt from, may lead him into a Method of Cure, which that Physician himself would not have pursued at that particular Time.

A P P E N D I X.

SINCE these Lectures were publickly read at the *College of Physicians*, I have carefully perused and considered the Experiments published in the *Philosophical Transactions*, N^o 441. for the Months *April, May* and *June, 1736*, which I had not met with before.

THEY were made by Dr. *Houſton* at *Leyden*, in the Years 1728 and 1729, and communicated to the Royal Society after the Doctor's Death, by Mr. *Miller*, under the Title of *Experimenta de Perforatione Thoracis, ejusque in Respiratione effectibus*.

THE two last of these Experiments were made ſo nearly in the ſame manner with Dr. *Hales's*, and the Second of our Experiments, mentioned in the First of these Lectures; that I was very much ſurprised, at first reading them, to find ſo great a Difference in their Events; and began to ſuſpect, that one or other of us had not been ſufficiently accurate in our Observations whilſt the Experiments were making.

BUT when I had more attentively weighed all the Circumſtances of each Experiment, I found that all the different Appearances, notwithstanding they ſeem ſo contradictory to one another, were the natural Conſequences of the Action of Respiration, as it is accounted for above, and are ſo many farther Confirmations of the Truth of what is there delivered.

I MUST, therefore, beg the Reader's Patience, whilst I transcribe the Doctor's Account of these Experiments, and endeavour to explain the Reason of the curious Phænomena which were the Consequences of them.

EXPERIMENTUM V.

“ 25 Jan. 1729. Cani mediocri, asseri alligato, Thorax apertus
 “ fuit utrinque, largo vulnere. Animalis vox non defecit, &
 “ pulmones adeo non collapsi sunt, ut per Aperturas eruperit
 “ utrinque illorum lobulus. Lobuli hi extus hærentes dilatari,
 “ & contrahi non desierunt; et quod maxime mirum, *dilatatio*
 “ illorum Thoracis *contractioni* erat *synchrona* & *contra*. Aer
 “ in pectoris cava inflatus animalis respirationi nihil nocuit.”

“ POSTQUAM sic per semihoram vixisset, sine ulla vocis,
 “ vel respirationis læsione sensibili; Thorax ab uno latere aper-
 “ tus fuit ulterius, discissâ cossâ. Tumquæ apparebat (magnum
 “ paradoxum) pulmonem *contrahi*, dum pectus *dilatabatur*, di-
 “ *latari* dum hoc *angustabatur*.”

“ HUIUS etiam operationi supervixit canis, donec re ab omni-
 “ bus abunde perspectâ, laqueo strangulari damnatus est.”

IT were to be wished the Doctor had been a little more accurate in giving us an Account of the Sizes of the Wounds, and between what Ribs they were made; but as he has not, we must endeavour to guess as well as we can.

FIRST, then, it is pretty evident, the first Wounds that were made were only longitudinal ones, between two Ribs; because the Doctor says, that one of these Wounds was afterwards enlarged, by cutting away Part of one of the Ribs: and that they were not *very* large, is reasonably to be supposed, both because the Dog lived above half an Hour without any sensible Alteration in his Voice, or Breathing; and because the Ends of the Lobes, which were thrown out, were stuck and held fast in the Wounds, so as to remain out even during Inspiration.

2dly, As

2dly, As to their Situation ; this seems to have been among the middle Ribs : for had they been made lower, the Lobes could hardly have reached far enough to have hung out ; and had they been higher, the thicker Parts of the Lobes would have been applied to their inner Orifices, and no Part been thrown out ; as it was in Dr. *Hales's* Experiment.

THE Appearances, upon first opening the Thorax, were like those in our first Experiment ; in which the Ends of the Lobes were very violently thrown out at the Orifice, and remained so some time. But the Motions of the Breast and Lungs, in our Dog, were so violent and irregular, and his Death so sudden, that we cannot recollect enough to determine us now to say positively, whether the Ends of the Lobes, whilst they were out, did alternately contract and dilate or no : But I am myself inclinable to think they did not, because, to the best of my Remembrance, they continued out only during the prolonged Expiration, and immediately collapsed upon Inspiration.

HOWEVER this be ; in the Doctor's Experiment, they continued out for a long time, and never ceased dilating and contracting ; and what was very surprising, they dilated when the Thorax contracted, and contracted when the Thorax dilated.

THIS Appearance we are now to explain. In order to this, it must be considered, that those Parts of the Lungs, which are within the Breast, are exposed to the Pressure of the Air within the Cavity ; and those Parts, which hang out at the Wounds, are exposed to the Pressure of the external Air ; and lastly, that all Communication is stopped between the Air within and that without, by the Parts of the Lobes thus forcibly thrust out at the Wounds at their first being made.

WHEN the Breast is contracted, the Air in the Cavity, being condensed, presses more forcibly on the Lungs within, than the external Air on the Ends of the Lobes without. In Expiration
a 2 therefore,

therefore, which is the Consequence of this superior Pressure of the Air in the Cavity, Part of the Air in the Lungs, which otherwise would have passed out at the Wind-pipe, will now be forced into the Ends of the Lobes, which hang out at the Wounds; by which those Ends must be dilated when the Breast contracts.

AND when the Breast is dilated, the Air in the Cavity becoming rarer, presses less forcibly on the Lungs within, than the external Air on the Ends of the Lobes without. In Respiration, therefore, which is the Consequence of the superior Pressure of the external Air, the Air will be forced out of the Ends of the Lobes back into the Lungs again; by which they must be contracted when the Breast dilates.

I SHALL defer the Consideration of the other Appearances in this Experiment, till I have explained those in the Doctor's Sixth; which, as they are of the same Nature with these, only more simple, ought first to be accounted for.

EXPERIMENTUM VI.

“CANEM parvulum, extensis artubus, firmiter super asserem
 “ligavimus. Cutis elevatæ portionem forfice abscidimus, eâ
 “Thoracis parte, quâ costæ ab incumbentibus musculis minime
 “teguntur. Absterfo sanguine, & fluxu ejus vini spiritu cohibito,
 “quicquid adhuc costas, & intercostales musculos tegebat,
 “id arreptum tenaculo abscidimus; tandemque et ipsos intercostales
 “musculos caute separavimus. Membrana Pleura dicta,
 “hoc modo nudata, hæcce aspicientibus exhibuit Phænomena.”

“DUM pectus *dilatabatur*, apparebat intus membranæ applicatum
 “aliquod *album*; dum vero *angustabatur* pectus & expirabat animal,
 “album illud sursum fugiens locum cessit ascendenti cuidam corpori
 “*rubro*; tumque mox *dilatante* se pectore, *rubrum* iterum descendit,
 “locum ejus occupante *albo*; & sic per vices.”

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“ Hoc viſo, *ſuperius* coſtarum *interſtitium* etiam muſculis nudavimus, ſed eo in loco apparuit *nihil niſi album*.

“ MEMBRANA, utrâque parte, quâ nudata erat, dum pectus *dilatabatur*, fiebat *concaſa*; dum *angultabatur* paululum (ſed vix ſenſibiliter) *convexa*.

“ HISCE ad ſacietatem contemplatis, diſciſſis duabus coſtis pectus aperuimus, tam amplo vulnere, ut quicquid fere in eo latere continebatur oculis pateret.”

“ ANIMAL, hoc factô, vocem non amplius edidit, quamvis ab altero latere Thorax ejus eſſet illæſus. Pulmo multum illi-
co collapſus eſt; ſed alternum dilatationis & contractionis motum non penitus amiſit: eratque omnium aſpicientium con-
ſenſu, *dilatatio* ejus *contractioni* Thoracis *ſynchrona*, & *contra-*
tra.”

“ CORDIS tandem ventriculus pertuſus eſt, ut intruſus digi-
tus ſentiret vim ejus muſcularem; ficque de Reſpiratione ſi-
mul et Vita actum eſt.”

THE latter Part of this Experiment only being to our preſent Purpoſe, I ſhall confine myſelf to that. And, here it muſt be obſerved, 1. That there was at laſt a very large Opening made into the Cavity of the Thorax; Part of two Ribs being taken away, ſo that three Interſtices were laid into one, and almoſt all the Contents of the left Side of the Thorax were expoſed to view: And, 2. that the lower Edge of this Opening was ſo near the Diaphragm, as to be within the Reach of it in Expiration; for the red Body, which was applied to the Pleura, when the Breſt contracted, was undoubtedly the Diaphragm.

WHENCE, and from what was ſaid above, it is eaſy to ſee, 1ſt, that the Ends of the Lobes could not be thrown out at the Wound, becauſe the Air in the Cavity had a free Paſſage into the open Air, as ſoon as it began to be condenſed in the lower Part of the Thorax: And, 2dly, by our firſt Experiment, that
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the Contraction and Dilatation of this left Side of the Thorax, could not produce any Difference in the Density of the Air within it, and consequently that whatever Motion was to be seen in this left Lobe, was not at all owing to the dilating and contracting of the Side of the Thorax which contained it.

IF, therefore, we would enquire into the Cause of the alternate dilating and contracting of this left Lobe, we must look for it on the right side of the Thorax, which was in this Experiment left untouched.

NOTWITHSTANDING, therefore, what had been done on the left Side, Respiration went on as usual, on the right. In Expiration, the Air in the right Lobe was condensed, and Part of it, instead of going out at the Wind-pipe, forced its way into the Left, and dilated it till the Air within it came into an Equilibrium with the external Air which surrounded it; and in Inspiration, when the Air in the right Lobe became rarer than the external Air, the left Lobe was compressed, and Part of the Air within it was, by the Pressure of the external Air, forced back again into the Right, till the Equilibrium was again restored.

THUS it is evident, that whilst the right Side of the Thorax is entire, the right Lobe will, when the Breast contracts, blow up the Left, and when it dilates, draw the Air out again and contract it.

THE Doctor seems to wonder at the Dog's immediately losing his Voice after the Wound was made, more especially as one side of the Thorax was left entire. Now, the Reason of this will very plainly appear, if it be considered, that tho' the Dog endeavours to cry, by making a forcible Expiration, and contracting the Orifice of the Wind-pipe, yet the Liberty the compressed Air has of escaping out of the right Lobe into the Left will prevent its passing out at the contracted Orifice of the Wind-pipe with such a Velocity as is required to produce the acute Sound of Crying.

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THE Pain, therefore, the Dog was in, and the fruitless Endeavours he made to express that Pain by Crying, must, by preventing the Air from going freely out at the Wind-pipe, greatly contribute to the blowing up and contracting of the left Lobe, by the contrary Motions of the Right.

Now, let us return to the latter Part of the Doctor's fifth Experiment.

“ POSTQUAM sic per semihoram vixisset, sine ullâ vocis,
 “ vel Respirationis læsione sensibili; Thorax ab uno latere aper-
 “ tus fuit ulterius, *discissâ cossâ*. Tumque apparebat (magnum
 “ paradoxum) pulmonem *contrahi*, dum pectus *dilatabatur*, di-
 “ latari dum hoc *angustabatur*.”

AFTER the Wound was thus enlarged on one Side, by taking away Part of the next Rib, the Dog was nearly in the same Condition with the Dog in our second Experiment, when upon taking out one of the Canulæ, we had enlarged the Orifice so as to be able to thrust our Fingers in and feel the Dilatation and Contraction of the Lobe on that Side the Mediastinum. Nevertheless, the Lobe which we felt in our Experiment, most undoubtedly contracted when the Thorax contracted, and dilated when that dilated; and in the Doctor's Experiment, the very Reverse happened.

Now, there were two Circumstances in which we differed in making our Experiments; and from these alone proceeded the Difference in the Times of the dilating and contracting of the Lobes under our Consideration.

IN the first Place, the Orifice in our Experiment was, on one Side, no larger than the Bore of the Canula of one of the Trocharts; and on the other, even when it was enlarged, it was not bigger than the smallest of the Doctor's.

AND in the next Place, the Mediastinum was pierced thro' in two several Places by the Trocharts, one of which was still remaining in the Breast, so that the Air in one Cavity could not be more dilated, or condensed, than the Air in the other.

BUT

BUT in the Doctor's Experiment the Mediastinum was entire, and the Wound, that was enlarged, was of a considerable Length, and as broad as two Interstices between the Ribs, together with the Breadth of the Rib taken away ; which must make a larger Orifice than that we made with the Trepan in our first Experiment, and consequently must prevent all Motion in the Lobe on that Side, which would otherwise have followed upon the contracting and dilating of that Side of the Thorax.

NOW, before this Orifice was thus enlarged, the Dog had lived near half an Hour with both Orifices open, without any sensible Alteration, either in his Voice, or in his Breathing : whence it is reasonable to conclude, that the Side of the Thorax, where the Wound was not enlarged, was still able to carry on the Office of Respiration with a tolerable Degree of Force.

CONSEQUENTLY, for the same Reasons that in the Doctor's sixth Experiment, the Lobe in that Side of the Thorax, which was entire, did alternately blow up, and exhaust the Lobe on the other Side ; it will follow, that the Lobe, on the Side where the small Orifice was, must, in this Experiment, alternately blow up, and exhaust the Lobe on the Side where the great Orifice was made, in the same manner, tho' not with the same force, as in the other Experiment ; and therefore the Lobe, on the Side where the great Orifice was, must contract when the Breast dilated, and dilate when that contracted.

BUT in our Experiment, no such contrary Motions could be produced in the Lobes, on the different Sides of the Mediastinum, both because neither of our Wounds were large enough totally to destroy the Action of either Side of the Thorax upon the Air within, and because of the free Communication which was opened by the Trocharts between the Air on both Sides the Mediastinum ; and, therefore, the Air in both Cavities must be condensed, and consequently both Lobes be contracted, when the Breast contracted ; and the Air in both Cavities must

be

be dilated, and consequently both Lobes be expanded, when the Breast expanded; which is agreeable to what we observed.

Thus have I gone thro' all the material Differences in the Doctor's Experiments, and ours; and shewn that they are agreeable to, and the Consequences of, the Account of Respiration, delivered above.

BUT tho' I was fully satisfied myself with this Way of explaining the different Appearances in these Experiments, I could not help employing a Workman to make a Machine I had contrived, by which any one may be experimentally convinced of the Truth of what is here deliver'd, without undergoing the uneasy Task of making Perforations into the Breasts of living Animals: And as this Machine does perfectly answer the End I propos'd, I have subjoin'd a Print of it to these Papers; and shall now give a short Description of its Make, and the Manner of trying the Experiments with it.

ABCDEF represents two Cubical Frames, made of Wood, joined together, and screwed into the Wooden Stand XYZ.

At the two Ends ABF, CED, and in the Partition between the two Cubes, three square brass Plates are cemented into the Frames.

IN each of these Plates is made a large Hole; and over that Hole, a circular Plate is fastened at its Center into the square Plate, so as to be moveable upon that Center; and in this circular Plate there is another Hole, which corresponds to that in the square Plate underneath it.

THIS is represented in the Figure at one end CDE, by the Letter P, and in the Partition by the Letter O; but that at the other End ABF is not to be seen, in the Position in which the Draught is taken; so that by moving the Plate P or O round upon its Center, you may either bring the two Holes together, or place them at a distance from one another, and by that means either open a Communication between the Air in both the Cu-

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bical

bical Boxes and the external Air, or prevent it; or by bringing the Hole in the circular Plate more or less over that in the square Plate, make the Communication greater or less. At the two Ends, the Plate P is easily moved by the little Nob p; but that in the Partition O is turned by a Key, which is occasionally put in thro' the Hole in the Plate P.

THE Four square Frames, which compose the two Sides ABC, DEF, have Pieces of Glass carefully cemented into them.

THE Top is an oblong Piece of Brass, cemented likewise into the Frame AFE, with two Holes in it, into which the hollow Tubes G and H are screwed. These Tubes G and H, are long enough to reach thro' into the two Cubical Boxes, one on each Side the Partition O; and to the Ends of these Tubes are fastened two small Bladders M and N, suited to the Size of the Boxes.

A COMMUNICATION is made from the hollow Tubes G and H, which are closed at Top, to the hollow Tube I, which is open at Top, by the short Pipes GI and HI: So that when Air is blown into the Tube I, it passes thro' the Pipes IG, IH, into the Tubes G and H, and thence into the Bladders M and N, and blows them up; and if those Bladders were to be squeezed flat again, the Air would be forced out through the Tube I.

THIS Tube I, therefore, represents the Wind-pipe; the Pipes IG, IH, and the Tubes G, H, represent the Bronchia, which go to each Side of the Thorax; the Bladders M, N, the Right and Left Lobes of the Lungs; the two Cubical Boxes, the Right and Left Cavities of the Thorax; and the Partition O, the Mediastinum. The little hollow Conical Piece of Brass, K, with a very small Orifice at Top, is contrived to skrew on upon the Tube I, occasionally, to shew what Effect diminishing the Orifice of the Wind-pipe will have in Respiration.

THE

THE Bottom of this Frame B C D, is made of Wood, and has two large circular Holes bored thro' it; and into each of these Holes is screwed a large Wooden Rim, to which is fastened tight one End of a large Bladder Q R, or S T; which Bladder is in the same manner cut at the other End, and tied round a large Cylindrical Piece of Wood R or S, which has no Hole in it. Thus is there a free Communication between the Air contained in these Bladders Q R, S T, and the Air in the Cavities of the Boxes immediately over them, which every way furrounds the Bladders M, N.

WHEN the Bladders Q R, S T, are wet, you may, by squeezing them hard, as is represented at S T, force the Air out of them into the Cavities of the Boxes; and by pulling the Bottoms forcibly down, by which you reduce the Bladders to their Cylindrical Forms again, as is represented at R, you may draw the Air out of the Cavities of the Boxes into those Bladders again. These Actions, therefore, if they are performed alternately, must alternately dilate, and compress, the Air in the Boxes, which immediately furrounds the other Bladders M, and N; and consequently produce the same Effects upon those Bladders, which the alternate enlarging and contracting of the Thorax does upon the Lobes of the Lungs on each Side of the Mediastinum.

IN order, therefore, to represent the Motion of the Lungs in natural and undisturbed Respiration, we close up the Hole in the Partition O, and blow in Air at the Tube I, till the Bladders M, and N, are blown up; leaving the other two Holes at the Ends open, that the Air in the Bladders, and in the Boxes, may be of an equal Density; and then we close the Holes at the Ends likewise.

WHEN this is done, if we alternately contract and enlarge the two Bladders R Q, S T; the Bladders M, N, will be alternately

contracted, and dilated, as the Lungs are in Respiration: and the Air will be alternately forced out, and taken in, at the Orifice of the Tube I, as it is at the Orifice of the Wind-pipe in living Animals.

WHEN both the Bladders, without the Boxes, are squeezed; as S T is represented in the Figure, the other Bladders will appear as N does; and when they are drawn out, as Q R is represented, those within the Boxes will appear as M does.

THIS being understood, it is easy to see how the Experiment may be varied by Means of the moveable Plates at the Ends of the Frame, and in the Partition, so as to represent the Motion of the Lungs, when Respiration is disturbed by Perforations made either into one or both Sides of the Thorax, or thro' the Mediastinum.

IT is sufficient to add, that I have made the Experiment in all the different Circumstances of Dr. *Houfston's* Experiments and mine, and found the Events in this Machine to answer exactly with the Descriptions given above.

I CONTRIVED a Way, of making an Experiment to answer the Fifth of Dr. *Houfston's*, in which the Ends of the Lobes were thrown out at the Orifice of the Wounds, and continued so for some Time.

I TOOK a small Cylindrical Piece of Cork, and thrust a Crow-Quill, open at both Ends, thro' it. This I dropt into the Bladder N, before it was fastened to the End of the Tube H; and when I had got the End of that Bladder out of the Hole, I held it fast there, by means of the Brass Plate P; so that notwithstanding it squeezed the Bladder tight upon the Cork within it, and so stop'd the Orifice close, there was a free Passage for the Air thro' the Crow-Quill to pass from that Part of the Bladder within the Box, to that which hung out at the Hole.

THE

THE Event was the same. The Part, which hung out, dilated, when that within contracted; and contracted, when that dilated.

I FOUND, likewise, when the Hole at P was made very large, and the Bladders M and N did in consequence of it dilate, and contract, at different Times; that they did it much more remarkably when the Orifice of the Tube I was diminished by screwing on the Piece K: Which is an experimental Proof; that the Dog's endeavouring to cry, in the Doctor's Sixth Experiment, contributed greatly to the Motion of the Lobe on that Side of the Thorax, where the large Wound was made; which in all Probability would not otherwise have been so discernible in the languid State the Dog must have been in, after so long an Experiment.

AND that all these different Effects depend entirely upon the different Sizes of the Apertures, may be seen experimentally, by this Machine, if at first we gradually open one only of the Apertures, *viz.* that at the End P, and afterwards the other, till they become of their greatest Extent; and all the while, continue alternately squeezing, and dilating, the Bladders Q R, S T.

FOR, 1. Whilst the Aperture at P is very small, in Proportion to the Space between the Bladder N, and the Sides of the Box which contains it; the two Bladders will dilate and contract together, and little or no Alteration will be made in the Motion of the Bladder N.

2. As the Size of the Aperture encreases, the Bladder N will have less and less Motion; but still the Dilatations and Contractions of this Bladder will happen at the same Time with those of the other.

3. IF the Aperture be still encreased, the Motion of the Bladder N will grow stronger again; and the more so, the more
the

the Aperture is encreased; but then it will dilate when the other contracts, and contract when that dilates.

4. BETWEEN the Times of the Motion of the Bladder N's diminishing, and afterwards encreasing again in a contrary Direction, there must be a Time, when it will have no Motion at all communicated to it, notwithstanding that the Bladder on the opposite Side dilates, and contracts, regularly; and consequently, there is one certain Size, to which if the Aperture P be opened, the Bladder N will be quite at Rest.

5. IF now the Aperture be gradually opened at the other End, there will be little or no Alteration in these Appearances, whilst it is very small; but as it gradually encreases, the Motion of both the Bladders will gradually decay, till they come to nothing.

AND, lastly, if at any Time during this Experiment, the Aperture at P, (or both of them, after they have both been opened) be stop'd up on a sudden; both the Bladders will immediately dilate and contract at the same Time, as they did at first; and in a greater, or less Degree, according as there was a less, or a greater Quantity of Air in the Cavities of the Boxes, when the Apertures were stop'd up.

IF we try the Experiment another Way, by gradually opening both the Apertures together, we shall find little or no Alteration at first, whilst they are very small; but as they encrease, the Motion of both Bladders will gradually decay, till they come to nothing; but they will all the while dilate and contract together.

MAY we not, from all these Experiments taken together, fairly conclude that Perforations may be made into both the Cavities of the Breast, nay, and thro' the Mediastinum too, without immediately killing the Person, provided those Perforations are very small; and consequently, that a Person may be run
through

through the Breast with a small Sword, without the Wound's being mortal, provided the Lungs themselves be not greatly wounded?

AND with Regard to Practice, may we not be certain that, in Cases of absolute Necessity, we may safely make a Perforation into the Cavity of the Breast, not only on one, but on both Sides, to let out either Water or a Collection of Matter, provided we make not the Orifice too large? And consequently, that the smallest Orifice, sufficient to let out the Fluid, is the best?

THAT if any Difficulty, Interruption, or Convulsion, in breathing, should happen upon the first making the Aperture, stopping the Orifice with the Finger, from Time to Time, whilst the Fluid is discharging, will most remarkably assist the Patient, and ease that Complaint? This I not only know from Theory, but from Fact also in two remarkable Instances.

AND as it is most commonly necessary, in Cases of this Kind, to keep the Orifice open, in order to procure a constant Discharge for some Time, that it is better to do it by leaving a Piece of Rag, or a Skain of Silk in the Wound, than by thrusting in a Canula; because in one Case, you leave an Orifice of a considerable Size open, and in the other you leave none, the Parts about it naturally sticking to the Rag?

WHAT I have here said with Regard to the Safety of making an Aperture into the Cavity of the Breast, relates only to the Motion of the Lungs in Respiration; which it has been generally supposed would be affected in the most dangerous Manner by it. And I think it evident from what has been said, that it may safely be attempted by any one, who takes proper Precautions, and knows where to make the Aperture properly, so as not to cut either an Artery, or Nerve, and to afford the readiest Discharge for the Fluid he wants to let out.

IT is to be supposed that no one will ever attempt such an Operation, but when he thinks a Life may be saved by it; and it must be right to have every one, who may possibly be called to perform it, apprized of the properest Way to do it, and of all the Consequences of it. Nor will it be a small Satisfaction to any one in such Circumstances, to know, by a Number of Experiments, that, if he be deceived in his Judgment, and there be no Fluid in the Cavity to let out, the Operation, properly performed, will not endanger the Person's Life; and that Respiration will go on, as well as if it had never been performed; and if so, that the Orifice will heal almost as soon as a common Issue.

THUS much I thought, it was proper to say on this Subject, not with a View to encourage any one to perform this Operation, without the strongest Proofs of its being the only Way to preserve the Patient; but in order to remove the Dread of doing it, when it is necessary, and to shew the properest Way of doing it with Safety: And what has more determined me to say so much of it, is, that I know it to be fact, that there is a young Gentleman alive, who underwent the Operation, and has enjoyed many Years of perfect Health, even since the Orifice was healed up.

I SHALL only add a few Remarks upon the first Part of the Doctor's Sixth Experiment; from which he seems a little too hastily to conclude, that the Lungs fill up the whole Cavity of the Thorax, (except what is taken up by the Heart, Pericardium, &c.) and have their Surfaces closely applied to the Pleura, whilst the Thorax is entire.

“ MEMBRANA, Pleura dicta, hoc modo nudata, hæcce aspicientibus exhibuit phænomena.

“ DUM pectus dilatabatur, apparebat intus membranæ applicatum aliquod album; dum vero angustabatur pectus, et expirabat

“pirabat Animal, album illud sursum fugiens locum cessit ascendenti cuidam corpori rubro; tumque mox dilatante se pectore, rubrum iterum descendit, locum ejus occupante albo, & sic per vices.”

“Hoc viso, superius costarum interstitium etiam musculis nudavimus, sed eo in loco apparuit nil nisi album.”

“MEMBRANA, utrâque parte, quâ nudata erat, dum pectus dilatabatur, fiebat concava; dum angustabatur, paululum, sed vix sensibilibiter convexa.”

“IN sexto Experimento,” says the Doctor, “Res ipsa loquitur album corpus Pulmonem fuisse, rubrum Diaphragma: Quin et Pulmones Thoracem integrum replere, ejusque Membranz superficie suâ applicari, ut vulgo creditur.”

IT seems, indeed, very evident, that the red Appearance of the Pleura, which is naturally white, was owing to the Diaphragm; because when the Pleura was laid bare, higher up, out of the Reach of the Diaphragm, there was no such alternate Appearance of red and white, *in eo loco apparuit nil nisi album*. But it is by no means so certain, that the white Body, as the Doctor calls it, was the Surface of the Lungs.

FOR, is it not reasonable to imagine, that there is a visible Difference between the Colour of the Lungs in Inspiration, when the Blood has a free Passage allowed it thro' all their minutest Vessels; and in Expiration, when those Vessels are squeezed together?

AND if so, would not this Difference be discernible thro' the transparent Pleura?

How then could the uppermost of the two Parts of the Pleura, which were laid bare, have the same white Appearance, both when the Breast dilated, and when it contracted?

MAY we not, therefore, just as reasonably assert, that the White was the natural Colour of the Pleura itself, and that the

Surface of the Lungs was not at all applied to it, either in Inspiration or Expiration?

THE Thing, therefore, does not speak itself so plainly, but that it will admit of Dispute, even if no farther Account had been given us of this Experiment : But there are some other Circumstances, which remain to be considered, and seem to me sufficient to determine the Point in dispute.

“ MEMBRANA, utrâque parte, quâ nudata erat, dum petus *dilatabatur*, fiebat *concava* ; dum angustabatur, *paululum*, sed vix sensibilibiter, *convexa*.”

LET us see how these Appearances will agree with both our Hypotheses.

THE Pleura, as it lines the Cavity of the Thorax, is extended from the internal Surface of one Rib to the internal Surface of the other ; so that, when it is laid bare by removing the intercostal Muscles, there is a sort of deep Furrow between the two Ribs.

IN Inspiration, the Ribs, more especially the middle ones, are at their greatest Distance from one another, and consequently, if no other Cause intervened, the Pleura which lies between them would be stretched so as to appear plane ; and if the Lobe of the Lungs, which is upon the stretch likewise in Inspiration, had its Surface applied to it, it would rather make it convex, than suffer it to be concave.

AND in Expiration, upon a Supposition that there is no Air in the Cavity, the external Air must keep the Pleura close to the Surface of the Lungs ; and consequently, as the Lungs subside, it must rather squeeze the Pleura inwards, and render it concave, than suffer it to be convex.

BUT on the Supposition, that there is Air in the Cavity of the Breast, and that the Surface of the Lungs is not every where applied to the Pleura ; it will follow, that in Inspiration, at which
Time

Time the Cavity is enlarged, and the Air within it is rendered more rare than the Air in the Lungs, or than the external Air, the Pleura will be more pressed on the Outside by the external Air, than on the Inside by the Air in the Cavity; and consequently must be pressed in, and appear *concave*.

AND in Expiration, when the Cavity is lessened, and the Superiority of Force is given to the Air within it, the Pleura must be pressed out, and appear *convex*.

I KNOW no Reason why the Concavity of it in Inspiration should be more sensible, than the Convexity in Expiration, unless it arises from the Situation of the Pleura at the Bottom of the Furrow between the Ribs. It may be, that when the Pleura is concave, the Whole of it, that lies between the two Ribs, is visible to the Eye; whereas when it is convex, its Edges are applied to the rounding Edges of the Ribs; and what is seen appears more upon a level, than it really is.

UPON all the Circumstances of this Experiment thus compared together, it seems more reasonable to conclude that there is Air in the Cavity of the Thorax; and that the Surface of the Lungs is not always, nor in every Part of it, applied to the Pleura; than the contrary.

I WOULD not, however, be understood, in Opposition to almost every one who has writ on this Subject, to assert, that the Surface of the Lungs, in a healthy State, is no where applied to the Pleura. On the contrary, it seems reasonable to believe, that at the Top, where the Shape of the Lobes so exactly corresponds to the Shape of the Thorax, their Surfaces are almost constantly applied together: But towards the Ends, where the Lobes grow taper, (and hereabouts the Doctor laid the Pleura bare,) I believe they are very rarely, if ever, in immediate Contact, in easy and natural Respiration.

THUS much I thought was proper to add upon seeing these Papers of Dr. *Houston's*; and I leave our different Ways of Reasoning

Reasoning upon the same Experiments, to the Judgment of the Reader. But I cannot conclude without taking Notice of the great Accuracy he has shewn in observing, as well as Faithfulness in relating, every the minutest Appearance that offered itself whilst he was making his Experiments ; for to these it is owing, if any Improvements have been made in the Reasoning upon them.

N. B. Having had an Opportunity of seeing a very exact Dissection of the Muscles, subservient to Respiration, which properly belong to the Ribs ; I thought it would be no disagreeable Present to my Readers, to annex to these Sheets as accurate Draughts of them, as I could procure.

THEY seem to me to be so exactly copied after Nature, and the Muscular Fibres are expressed in so masterly a Manner, that they require no particular Explanation. It were Pity indeed to spoil their Beauty by a Number of References.

ERRATA.

Page 10. line 13. and in other Places, for *Hæmæstâticks*, read *Hæmæstâticks*. P. 16. l. 6. from the Bottom, and in other Places, for *forceable* read *forcible*. P. 18. l. 12. from the Bottom, for *every* read *each*. P. 31. l. penult. after *Viscus*, for a, make a . ; and blot out the last Line entirely. P. 47. l. 10. for *of component Particles* read *of the component Particles*. P. 48. l. 4. from the Bottom, for *Vapour* read *Vapours*. P. 51. l. 8. from the Bottom, for *all that can be*, read *what is there*. P. 58. l. 16. for *Breathe* read *Breath*. P. 99. l. 6. from the Bottom, for *Alvini* read *Alvi*. Append. P. 6. l. 14. for *into* read *to*. P. 12. l. 18. dele *with*.

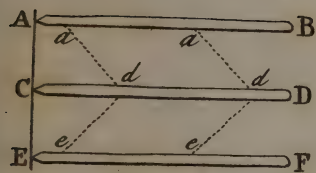
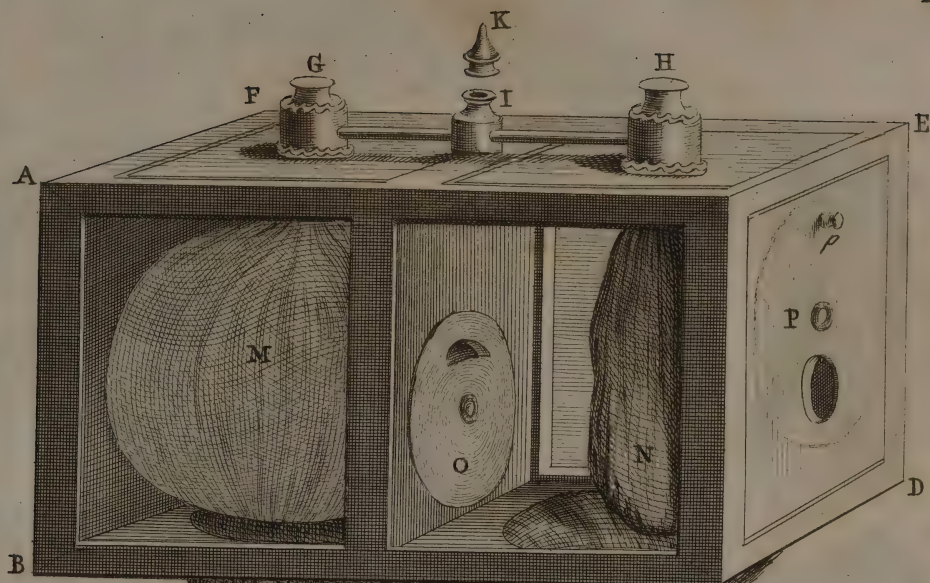


Fig. I.

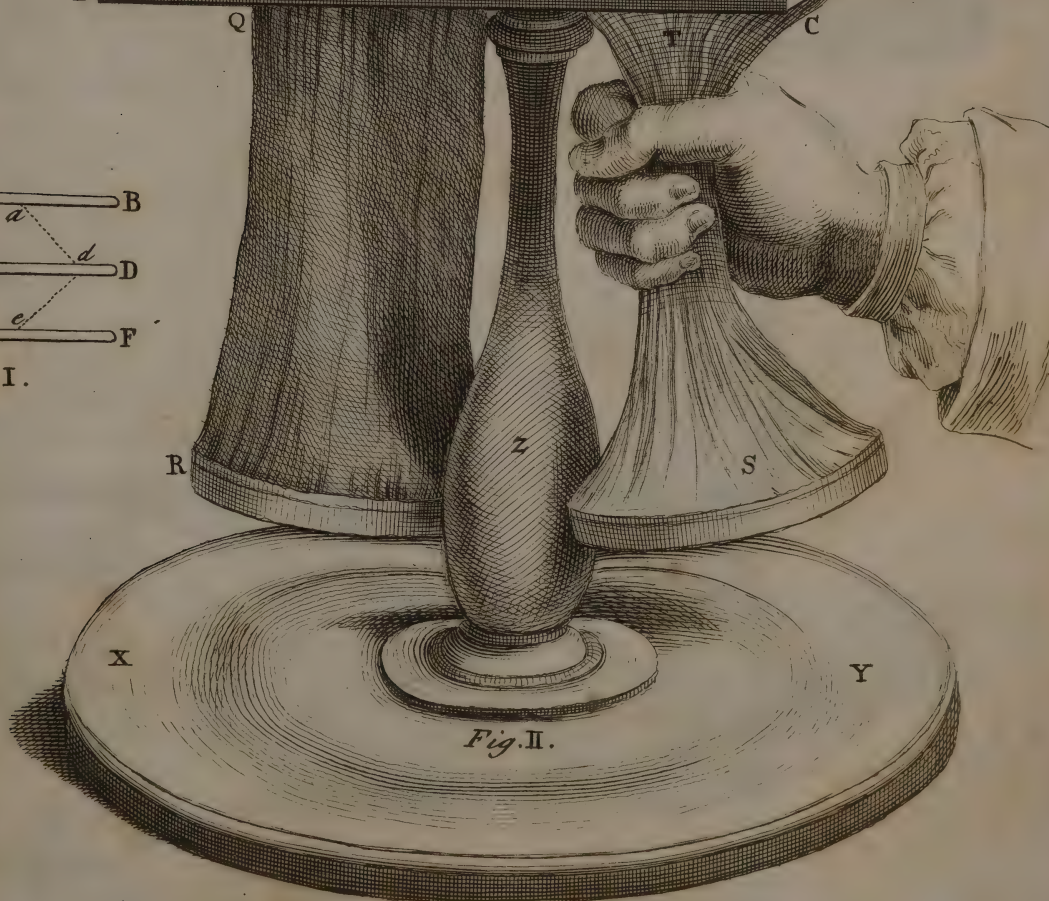


Fig. II.

